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Journal of the Society of Arts.

FRIDAY, AUGUST 13, 1869.

Announcements by the Council.

National Elementary Training and Education.

The following letter, covering copy of the *Journal* of last week, has been addressed to Mr. J. C. Bennett, Chairman of the Board of Management of the District School at Anerley :—

Society for the Encouragement of Arts, Manufactures,
and Commerce, John-street, Adelphi,
London, W.C., 6th August, 1869.

Sir,—I am directed by the Council of the Society of Arts to express to yourself and your colleagues, forming the Board of Management of the Anerley District School, their sincere thanks for the opportunities afforded them of inspecting the working of the school. The Council have derived great gratification from their two visits, and hope you will allow them to record their opinion that the extended knowledge of this and similar schools must be of immense importance to national education in the future. The Council find here conclusive evidence that children, from a low social and physical level, may be trained into health and activity, and taught the practice of different industries, upon a system which, at the same time, enables their intelligence to be cultivated with much less labour, and in a shorter period, than if they were kept entirely to book-learning, as in ordinary schools. With regard to the bodily training of the children, the Council would observe that their high appreciation of the advantages of the practice of the military drill is corroborated by the independent practical experience of distinguished members of the Society of Arts and others, extracts from whose evidence will be found at page 729 of the *Journal* of the Society, transmitted herewith. The Council have been deeply touched by the fact that poor children are, by means of these schools, rescued from that vice and neglect which would otherwise leave them to become a costly burden to the State, and are converted into useful members of the community, amply repaying the cost which the country has incurred on their behalf.

I have the honour to be
Your obedient servant,
P. Le Neve Foster, Secretary.

J. C. Bennett, Esq., Merton, S.W.

Examinations, 1870.

The Council have this year decided to remove from the Programme those subjects in which the Science and Art Department holds examinations, which, it appears, are now largely taken advantage of by the same class of persons (and very often by the same individuals) as those who sit at the Society's examinations. The following subjects will therefore not appear in the programme for 1870 :—

- Algebra.
- Geometry.
- Trigonometry.
- Conic Sections.
- Navigation, &c.
- Principles of Mechanics.
- Practical Mechanics.
- Magnetism, Electricity, &c.
- Light and Heat.
- Chemistry.
- Mining and Metallurgy.
- Botany.
- Animal Physiology.
- Free-hand Drawing.
- Practical Geometry.
- Mechanical Drawing.

Owing to a prize of £5 having been kindly offered by Earl Fortescue, President of the British Branch of the International Decimal Association, the subject of the Metrical System will be retained.

The programme is now in preparation, and will include some further modifications in the system, but the above, being by far the most important, are announced at the earliest opportunity.

Designs for Channel Steamers.

The very defective state of the accommodation afforded by the Channel steamers, plying between this country and the Continent, having been brought under the notice of the Council, they have determined to offer the Gold Medal of the Society, and the large Silver Medal of the Society, for the best and the second-best block model of a steamer, which shall afford the most convenient shelter and accommodation to passengers on the deck of the vessel crossing the Channel between France and England. The steamer is not to exceed in tonnage and draught the best vessels now in use between Folkestone and Boulogne, and the model must be on a scale of a quarter of an inch to a foot. The models, marked in cypher, are to be sent in to the Society of Arts' House, John-street, Adelphi, on or before the 1st November, 1869, with a sealed envelope, giving the name and address of the designer.

The Council reserve the right of withholding either or both medals, in case, in their opinion, the models sent in do not possess sufficient merit.

The following particulars of the South-Eastern Channel steamers, *Victoria*, *Albert Edward*, and *Alexandra*, are given for the convenience of competitors, but it is not intended to confine the designs to them, except as to tonnage and draught :—

Length between perpendiculars, 200 ft.
Breadth of beam, 24 ft.
Depth underside of deck amidships, 12 ft. 6 in.
Draught of water, 7 ft.
Bow, clipper.
Stern, elliptic.
Rig, polacca with two masts, lug foresail, gaff mainsail, staysail, and flying jib.
Engines, oscillating.
Paddle wheels, 17 ft. 6 in. diameter.
Tonnage, 568 tons.
Speed, 17 miles an hour.

Subscriptions.

The Midsummer subscriptions are due, and should be forwarded by cheque or Post-office order, crossed "Coutts and Co.," and made payable to Mr. Samuel Thomas Davenport, Financial Officer.

Proceedings of the Society.

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Cantor Lectures.

ON APPLIED MECHANICS.

By John Anderson, Esq., C.E.

Lecture III.—Delivered Monday, April 26th.

Applied Mechanics in Relation to Natural Laws in Processes.

In the last lecture I endeavoured to give a few examples of the advantage taken of some of the natural properties which govern materials. The subject selected for this lecture will refer chiefly to certain processes carried on in the workshops of applied mechanics, and to the natural laws by which they are governed, so far as I may know them.

The processes of art which have now to be considered are some of the more common in the engineering workshop, in connection with practical operations for changing the form or condition of metal, and especially iron, under its three states of cast-iron, wrought-iron, and steel, states or conditions so distinct as almost to constitute them into three different metals. Cast-iron, wrought-iron, and steel are all of a crystalline structure; these crystals are of various forms and dimensions, but their arrangement within the mass seems to be governed by fixed natural laws. Even in the case of fibrous wrought-iron, the collateral fibres are either crystals or were elongated from crystals. With cast-iron and steel, this condition is still more evident. Mr. Mallet was the first to draw attention to what appears to be the natural law which governs the order of crystallisation in cast-iron; and, whether right or wrong, and although such knowledge at the time may not have seemed of much value, yet in a few years we find that even such a small hint at nature is already beginning to influence the shape or form of mass which is now given to large castings by our foremost engineers; and if this law, even so far as it is yet known, is strictly obeyed, a higher result will be obtained with a given expenditure of metal than by following the rule of thumb, regardless of the natural law. Careful examination of many fractured castings goes to show that the direction and arrangement of the crystal formation of a cast-iron structure depends entirely on the outward form or shape of the casting, as governing the direction of cooling, the shape or form determining the nearest point into space at which the heat can escape from the melted metal, the formation of the long axis of the crystals being in the line of direction in which the waves of the heat current are passing from the interior mass to the nearest point of exit.

This being the case, a very important practical lesson is taught, namely, that much depends on form and the surroundings of the casting; that the outward shape or form of a casting really determines the direction of the heat motion outwards; and it points out that any sudden alteration of the outward shape introduces elements of discord in the order and direction of crystallisation, which again introduce points of weakness in the structure wherever the order of crystallisation is disturbed. This was clearly shown by the celebrated hydraulic cylinder accident which occurred in raising the Britannia Tubular Bridge. The accident arose from the form of the first cylinders being imperfect. The cylinders were made with a flat bottom, like that of a drinking-glass (as shown in Fig. 15); the cylindrical part of the casting had the crystals radial from the inside, but in the bottom part the crystals were perpendicular, and at the points where the two different arrangements of crystals come together at an angle, namely, at a line drawn from the inside to the outer corners, there were the lines of weakness; hence it was that, although considerably thicker, the cylinder failed at those points, much in the same manner as we have seen too often in many other cylinders, castings, and guns which have gone before and since, and for the same reasons. The second or substitute cylinder was made with a hemispherical end (as in Fig. 16), and was so far perfect, as in it the radiating crystals were all arranged in lines more nearly parallel, although, of course, not truly so. As thus made, it was found to be amply sufficient in strength, even with the same amount of metal in the mass. The foregoing accident was the means of drawing public attention to the subject. Many engineers found it to agree with their former experience, and many had previously been modifying their forms without knowing the precise law.

Fig. 15.

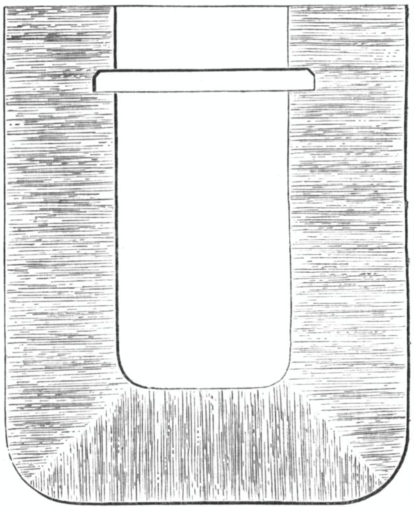
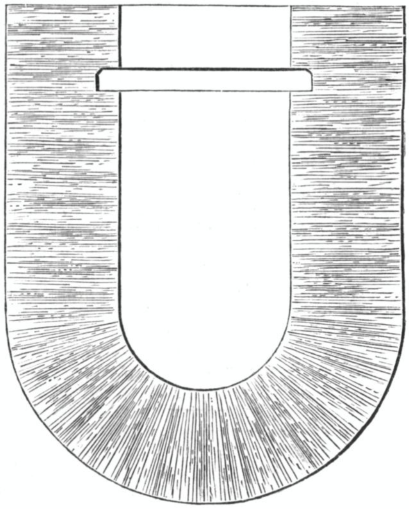
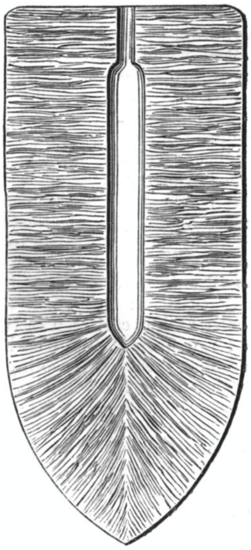


Fig 16.



The subject is well illustrated by a singular phenomenon that occurs in the process of casting chilled shells, wherein, from the effect of the sudden deprivation of heat, the shells have the lines of crystals clearly marked, and, when broken, show the order of crystallisation most convincingly. In such shells there occurs an apparent inconsistency with this reading of the law, namely at the point of the shell where, in every case, the crystals take a curved direction rather than straight out into space (as shown at Fig. 17), which I believe is entirely due to the following reason:—The shell is cast on end, with the point downwards. When the liquid metal is poured into the mould, it is, as a matter of course, in contact all over; and during the period while it remains a liquid, it naturally follows the gradually expanding mould or vessel in which it is contained; but as it begins, from the effect of the chill, to form an exterior crust, the time arrives when the body of the casting may not be in actual contact, and, consequently, the rate of conduction of heat is thereby lessened, but not so with the point of the shell, which is kept at the bottom of the mould by the effect due to the gravity of the mass; hence the point of contact becomes a new line of direction, competing with the sides of the mould, and the effect of the two determines the curved form of the crystals, as shown in every instance.

Fig. 17.



The distinct knowledge of this law as affecting cast-iron, when it permeates the working world more completely, will in time affect all our shapes or forms, more especially in such cases as I have mentioned, but still more so in regard to cast-iron guns, where the highest conditions are required. If there be any truth in this reading of the natural law, almost all the forms which have been given to guns in former times were so far wrong. The exterior form of cast-iron guns in past times, with their numerous projections and irregularities of figure, were no doubt given to please the eye of the designer, and, by a rule-of-three process, the thickness of the mass at every point was determined by the presumed strain. This mode of treatment might have been nearer to correct proportions provided that the material had been of the homogeneous nature which it was then supposed to be, and which it is even now generally considered to be, but still it was wrong, because such forms introduce points of weakness at the junction of the crystals, especially at the breech and trunnions; and as the strength of anything is only that of the weakest part, and as the weakest part of the cast-iron structure is at that point where the greatest currents of heat have taken divergent directions in leaving the castings, it is a very suggestive consideration indeed. This is a subject which deserves the strictest attention, both from theoretical and practical men, and when it comes to be thoroughly known it will gradually lead to the use of cast-iron for many purposes where the more expensive and more reliable material of wrought-iron is now employed, for at the present time cast-iron is frequently considered uncertain for many purposes although this uncertainty arises in a great measure from man's own doings, perhaps as much from indifference as from ignorance; but disobedience to natural laws is punished whenever they are broken, whether men understand them or not; it is therefore satisfactory to find a little fresh light brought to bear on a subject hitherto rather obscure. The Americans are now constructing their cast-iron guns in form like a soda-water bottle, which is nearly in strict accordance with this law of crystallisation. The exterior surface is arranged so as to invite the heat outwards in a nearly uniform current in all directions; this, together with great attention paid to other details, affords a quality of guns almost as good as wrought-iron, which, however, has to a great extent been undone by a departure from compliance with another law in the matter of cooling, which will be referred to afterwards.

A considerable degree of popular error exists in regard to cast-iron, as determined from the colour, appearance, and size of the crystals when a mass is fractured. With any particular brand of cast-iron alloy, as consisting of uniform or of varied proportions of iron and carbon with other impurities, coming from one locality, it is, perhaps, possible for a man to become by long experience, so thoroughly familiar with its composition, behaviour, and quality, as to enable him to determine with some degree of accuracy its character from the appearance only; but in examining and dealing with iron in a general way, when consisting of all sorts of alloys, such a discrimination is fallacious, because the appearance which the fracture presents depends not only on the chemical compound, but also in some measure on the degree of heat given to the iron before casting, very much on the size of the mass into which it has been cast, and greatly on the time given to the heat to leave the casting, as well as on the direction of the conveyance of the waves of heat outwards. It thus becomes a very complicated problem. Most engineers who have studied the subject are aware that, by a process of slow cooling, or with a great mass of metal, the crystals may, and mostly always do, show a large and granular structure of a grey colour, while the same iron, if treated with more rapid cooling (and more especially if in a smaller mass), will invariably show a close white brittle appearance, with all the carbon apparently chemically combined as in fine steel; and with an intermediate rate of cooling and other conditions, the appearance is neither white nor grey, but mottled, showing the carbon to be partly combined and partly uncombined; this goes to show that the appearance must be an unreliable guide to judge from.

As the attainment of a high degree of goodness in most materials, but especially in cast-iron, depends on a great number of minute points in the workshop processes, which too frequently escape the notice of the busy worker, it may be worth while referring to some of the more prominent causes that affect goodness of quality, as depending on the process or other collateral conditions.

The nature or quality of cast-iron that may be termed goodness, depends on the object which is to be accomplished, because goodness for one purpose may be the reverse for another; that for a hydraulic cylinder is not necessarily the condition that would afford goodness for a gun. For the hydraulic cylinder, the quality of goodness depends on high tenacity combined with density, and with a moderate share of toughness; ductility here is not a virtue, but, on the contrary, it is a great disadvantage. The conditions of goodness for a gun are much of the same nature as the qualifications required for a large cog-wheel subjected to desultory working; high tenacity is most desirable, but toughness, as depending on elasticity and ductility combined, are much higher considerations. As a general rule, it may be said that for all such purposes the best combination of all the good properties is attained the most readily by mixing a variety of good sorts, even when of the same character—and the greater the variety of natures of iron, so much the better result will be obtained—rather than by mixing opposite sorts in order to get the medium, which is sometimes done, such as mixing white with grey, to obtain a mottled. Re-melting several times adds to tenacity, but it tends towards brittleness. The effect of fluid pressure, as derived from a head of metal, is to increase both density and tenacity, and to some extent, ductility, but if carried too far it soon interferes with toughness; a "dead head" experiment of 30 to 40 feet produced hardness and tenacity, conditions suitable for the hydraulic cylinder, but which would be fatal to a gun at powder-proof. As a rule, in practice, the greatest toughness and ductility is obtained by a mixture of the stronger sorts, that give neither hardness nor softness, but something between the two, by which means toughness is secured, and the metal when subjected to the cutting instrument, as in a lathe, shows this condition when it cuts off in long massive shavings rather than in chips, which fact, together with the results of the testing machine in regard to tenacity and elasticity, afford the kind of information that will enable an opinion to be formed.

In America, with certain mixtures that afford elasticity, ductility, and toughness in a high degree, they have by this treatment been able to combine with those properties a tenacity above 13 tons per square inch, and with the limit of elasticity about one-third of the ultimate tenacity; a mixture which stretches before breaking ·003 to ·004 of its length. These are high results, and deserve our careful consideration. In this country, by mixing with a small portion of Titanic iron even higher results have been attained, up to the vicinity of 15 tons per inch, but this is exceptional.

Cast-iron and cast-steel very much resemble each other in several respects, with this difference, that the one is a coarse alloy of iron and carbon with other impurities, while the other is a much purer alloy of iron and carbon, but both are governed by the same laws to a great extent; both can be cast into moulds of any form; both can be made hard or soft, tough or brittle, and these changes can be effected in both by the same expedients. Cast-iron may be said to have scarcely any malleability—the slight amount shown in the softer varieties is almost inappreciable. In this respect there is a wide difference between the two, as well as in regard to their strength and elasticity and other properties.

The natural law that governs the molecular conditions of those two metals in affording hardness, softness, elasticity, brittleness, toughness, or tenacity, is not yet clearly understood; but this obscure subject is now being so closely investigated, and from the accumulated knowledge of facts which exist on every point, it is probable that the subtle chemical composition of cast-iron and steel may be more readily determined than it is at present, and that the various physical laws by which its strength and behaviour, as depending on composition and cooling, are regulated, will soon be better known. Whenever this is accomplished, and the precise knowledge of the laws has begun to bear fruit in the practical operations of the foundry, a complete revolution, in the applications of cast-iron especially, will be effected.

From my previous remarks, it will thus be inferred that we are yet groping in the dark after the precise knowledge of some of the conditions that will afford certain goodness, for each of the various requirements of peace and war.

As a rule, the hardness of all such cast-iron or steel is influenced by the rate of cooling. If they are made red-hot and suddenly deprived of heat, the crystallisation of the molecules is in a condition of rigidity with regard to each other; the particles are each fixed in their particular places with relation to their neighbouring particles; they require more time to arrange themselves comfortably, and thus establish a position of more friendly relationship, and hence they receive the appropriate name of being hard, and at the same time have an accompaniment of brittleness.

When the drinking-glass leaves the hands of the maker, it is so hard, rigid, and brittle as to be unfit for any useful purpose; but by subjecting it to a long-continued red heat, and then allowing it to cool down very slowly, the crystals have time to re-arrange themselves in an easy position, and the glass becomes what is termed soft, and not nearly so brittle.

This remarkable property of extreme hardness which cast-iron possesses when suddenly cooled is largely taken advantage of in the mechanical arts, and although considerable attention has been given to the subject, in order to arrive at the natural law, still there is some obscurity. One thing is clear, that the capability of hardness, both of cast-iron and steel, depends on the presence of carbon; and as cast-iron in the normal state contains such a large proportion of carbon, both combined and uncombined, the hurried cooling from the liquid state may combine with it the whole or a large proportion of the carbon, by not giving the necessary time for that which would otherwise be uncombined to separate from the iron, which it always does, more or less, when abundant; that is, when the mass is cooled more slowly, and thus there is an opportunity for the separation to take place; for time is an important element in nature.

Without being able to give the law by which the molecular change is effected to produce hardness, still sufficient is known to establish the general nature of its behaviour in practice, namely, that the hardness depends on the presence of combined carbon, and upon the rate at which the heat is conducted from the liquid and hot casting, and also upon the direction in which the crystals arrange themselves, as due to the direction of the heat-current outwards.

The mode of casting and cooling iron in moulds determines the condition when the property of hardness or softness of castings is wanted; those parts that are required to be soft have the mould-surface made of some slow-conducting material, such as sand or other earthy matter, in order to convey the heat slowly; while the parts that are required to be hard have generally a mould-surface of some metal, simply because the metal is a better conductor of heat. Any cause or condition that affects the rate of conduction or radiation tells upon the hardness and its opposite.

In this way the bush of a carriage wheel is usually made, with a soft exterior, accompanied with toughness from having been cast in a slow conducting sand-mould, while the interior of the bush, which moves on the carriage axle, is made as hard as glass by the use of a better conductor of heat, namely, a piece of steel to form the core interior, or by heating the steel beforehand, the hardness may be modified as desired. As the metal flows into the mould and surrounds it, it soon contracts, and grips the steel core; it is thus more quickly deprived of its heat by conduction than is the case with the opposite conditions, as in a shell where the mould does not grip, but, on the contrary, expands.

In America, the greater number of the railway wheels are made of a suitable cast-iron, with a hard exterior surface, so that it may last a long time, but the remainder of the wheel is left soft and tough, so that the wheel, as a structure, may not be brittle. This is accomplished by placing an iron ring to form a part of the mould, the ring being of the required shape, in order to form the hard rolling surface of the wheel, while the remainder of the mould is made of common moulding-sand. On the same principle the large cast-iron finishing-rolls, which are now used by the makers of plates and sheet-iron, are all made in an iron mould, while the ends that form the axle are cast in sand; thus the axles are soft and tough, while the surface of the roll is extremely hard, and takes a smooth polish.

From the circumstance of one part of such a casting having one portion of the mass with its molecular structure thus rigidly under constraint, and another part adjoining in a state of liberty, conditions are set up which render them much more liable to spontaneous fracture than when the whole is under easier conditions; and, as a corrective, such castings are frequently put into a hot oven, and allowed to cool down gradually over a period of several days, thus giving the mass time for its molecules or crystals to come to a better arrangement. The American railway wheels are now treated in this manner, and with great advantage in point of safety.

Major Palliser's chilled shot and shells, as their name implies, depend for their hardness on the chilling effect of an iron mould, so as to carry off the heat of the liquid iron more rapidly, while the rear or middle part of the shot is left soft by the use of a sand-mould, or by warming the iron mould up to a temperature of 200°; both the hardness and depth of the chilling are increased, which at first sight may appear a paradox, but it will be seen, from previous remarks, that to pour metal into an exterior mould of metal, is very different from casting metal round a mandril or core; in the former case, so soon as a thin shell of liquid metal is formed from coming in contact with the cold mould, then the thin shell will hold the liquid metal, and, after all is solid, it contracts, while the mould, as the agent of conduction, expands, and at first leaves the thin newly-formed shell to be partially softened by the influence of the warmer liquid in the interior; whereas, if the mould had been warmer before casting, it would not have left it either so soon or so far; hence the advantage of raising the temperature. In the latter case, where the metal contracts on the core, and the core expands in the metal, an extremely hard chilling is effected thereby, as compared with the opposite conditions of the former case.

The important point to understand in regard to all these instances of hardening by a chill is, that hardness or softness does not depend on the sand mould or the iron-mould as such, except in so far as and simply that they differ in regard to the rates at which they severally convey heat from iron combined with carbon, thus affording a rigid or a more easy settlement of the particles. Any other substances fulfilling the conditions would answer the purpose equally well.

In making a comparison of cast-iron with steel, it has to be remembered that the former is an extremely impure substance or alloy, while steel is a pure combination of the finest iron with the finest carbon; hence it is, that notwithstanding the hardness and strength of chilled cast-iron, it is still unfit for good cutlery or other similar purposes; but its cheapness recommends it for such uses as have been enumerated, where fineness of quality is not of consequence, but where hardness, strength, and cost are the chief considerations. At the same time it is sometimes employed for inferior cutlery, even when the articles are not made merely to sell.

The same natural law that works such a change in the molecular condition of cast-iron also applies to steel, but in a less degree, as modified by the smaller quantity of carbon with which the iron is combined, probably from 1 per cent. in the higher quality, down to ·03 per cent. in the mild quality, which is only a stage removed from wrought-iron, but yet with sufficient carbon present to enable it to be melted, without which it is more refractory, indeed almost impracticable with ordinary means.

The rate of conduction, as determining the degree of hardness in steel, is clearly shown by the various modes of treating that material which have been resorted to. From its great value as well as from its purity, steel is treated with great care in all its processes, especially in regard to heating, so that it may not be over-heated, as fire is its great enemy, but also that there may be no impurities in the fuel to risk the injury of the molecular properties. When a piece of steel is heated to redness, and then dipped in liquid mercury, the sudden chill gives it a degree of hardness beyond any other liquid. A drill hardened in this metal, or by other means equally rapid, will drill into ordinary tempered steel with impunity. There are also other liquids that conduct heat more rapidly than water that are often resorted to in the arts, as, for example, in hardening the tool termed a file, which is required to be extremely hard. After the teeth are formed the file is made red-hot, and is then dipped into a liquid denser than water, either brine or other similar dense mixture; but the only virtue of the brine lies in its greater rate of conduction as compared with water. In the case of hardening what are termed half-round files we have an interesting illustration of the natural law. If the half-round file is dipped into the brine perpendicularly like other files, it is, as a rule, bent or curved thereby, from the larger extent of surface which it presents to the liquid upon the half-round side, thus contracting and fixing its particles sooner than on the other side; but it is found that by moving it in the brine, with the flat side to take the fluid pressure, the skilful workman manages to keep the file straight by this mode of cooling, and so fixing both sides uniformly. Ordinary articles of steel are cooled in water, and thus receive great hardness with brittleness. The former would not be objected to, but for the other accompaniment; it is therefore necessary, for most purposes, to temper the hardness by liberating the particles to some extent, which is done by subjecting them to a low gentle heat. Fortunately a piece of bright steel when so treated changes colour, first to yellow, and then from yellow through all shades, down to blue, and the workman, knowing the required amount of hardness to leave in the article, takes advantage of the changing hue as an index, and drops it into water when it has reached the exact shade of colour which indicates the measure of *hardness* or temper intended. For other articles various means either to cool rapidly or slowly are resorted to. Extremely small articles are heated in the flame of a lamp, and then pressed between two pieces of cold metal. The long fine steel wire used as mandrils for drawing fine tubular wire upon, is first heated to redness in a furnace, or rather in a red-hot oven; then, to ensure perfect straightness as well as hardness, it is laid on a cold iron plate, which has been planed to a flat surface; another similar plate is laid upon the red-hot wire, and is rolled backwards and forwards until it is cold, thus straightening the wire and hardening it at the same time. There is a remarkable property of steel not known so generally as it should be; it is in regard to the hardening and tempering of steel without reducing, which, in a certain sense, may appear to have some resemblance to the custom of warming the iron of a chilling-mould as before referred to, in order to modify the hardness and toughness of the cast-iron shell. It is found that, by subjecting the steel to a lower temperature than that which is required for high hardening in the usual manner, and then reducing by tempering, if instead thereof, before dipping, a lower heat is imparted and then chilled, the hardness and toughness are greatly modified for the better. Every piece of steel, as depending on the amount of carbon which it contains, has a certain definite degree of heat, and if this is carefully ascertained beforehand, and the steel is then skilfully brought up to it, then dipped in water or oil in the usual manner, it will thereby receive a degree of hardness combined with toughness, far exceeding the same combination of properties when arrived at by the common method of first over-hardening with a higher heat, and then restoring the toughness by setting the extreme hardness at liberty by reduction. Punches for forming holes in iron, when so made, will perform several times as much work as a punch made in the ordinary manner; but a greater degree of skill and attention is required from the workman than by the other way, which is probably the cause of its being less frequently employed.

In considering the good qualities arrived at by the treatment here referred to, the effect depends on two conditions: first, the amount of carbon in the steel, and second, the rate of cooling. If the steel is not so steely, more heat is necessary; if, on the other hand, it is a high steel, then less heat is required. By keeping these two conditions steadily in view, some highly important practical results follow, which may be readily obtained by the skilful and observing workman.

In selecting water or oil as a cooling or tempering medium, due regard has to be paid to the purpose to be effected. If hardness with moderate toughness is wanted, then the rate of cooling has to be hastened, and water is used; if, on the other hand, toughness alone is the desideratum, then the slower conductor, oil, has to be chosen. It is supposed that the use of oil for tempering steel has been employed for twenty centuries, still it is only within the past few years that the principles here referred to have attracted sufficient attention to influence the use of steel in large masses, and to reduce it to a reliable working system for the attaining of toughness by a combination of the proportion of carbon, the temperature, and rate of cooling, as depending on the nature of the steel and the object to be secured.

The tables prepared from experiments made by Mr. Kirkcaldy were the first-published statement of the great increase of strength secured by tempering high steel in oil, but it was not generally known that this great increase of ultimate strength was combined with a doubling of the limit of elasticity in addition. This knowledge has led to important practical results, especially in regard to the construction of rifled cannon. In a cannon the whole strain of the explosion comes upon the interior surface in the first place, which has necessarily to be strained before any stress reaches the successive layers of matter lying beyond. Wrought-iron, being much exposed to small defects, is objectionable; hence there existed a craving for a steel interior, on account of its closeness and tenacity, but few were willing to venture on that material, because of its brittleness. The discovery that the elasticity, ductility, and toughness were both largely increased by the process of tempering in oil came most opportunely, and has been successfully turned to practical account at Woolwich and elsewhere, especially in the construction of an interior lining for guns, a purpose for which it is admirably adapted.

This great success is mostly attributable to the means adopted to know the relationship of the carbon in the steel to the most suitable temperature when cooled in oil that will afford the highest result. To accomplish this, two sets, of three specimens in every case, are cut from the steel block or barrel which is to form the interior part of a gun, both of which are tested; one set is to find the best heat for ultimate strength, ductility, and elasticity, the other is to find the best heat for toughness. For both purposes three pieces are cut from the mass, in each of which one piece is tested in its natural state; another piece after being tempered with a rather high heat and then a dip in the oil. Then the third piece brought to a rather low heat and a dip; all three are then pulled asunder, and their behaviour recorded as regards tenacity and limit of elasticity. A similar course is pursued in order to find the best heat for toughness; then the several specimens are bent to see the effect as regards this quality of toughness, after which the result of the whole is carefully summed up, and the heat determined upon to which the large block or band is to be subjected before dipping in oil. Had a less efficient system been adopted in the first instance, its value to the world might have gone unappreciated, as with overdone or underdone heating at the outset it would have ended in failure, and raised a groundless prejudice against the system.

The steel used for the lining of guns is what is termed mild; it contains a proportion of carbon in the vicinity of ·03 per cent. Its ultimate strength is in the vicinity of from 30 to 35 tons, but by tempering in oil at the proper heat it rises to from 40 to 50 tons; this, however important, is not to be compared with the advantage derived by its other property of elasticity. In the natural state, the limit of elasticity is from 13 to 15 tons, according to quality, but when tempered in oil this rises to from 28 to 32 tons. The peculiar virtue of this process consists in the combination of toughness with elasticity, by which the steel acquires the property of a spring in receiving the impact due to the blow from explosion, and then springs back into its normal state. According to quality, this mild-tempered steel is found to stretch from 15 to 25 per cent. of its length before breaking, showing a degree of ductility only excelled by the best Yorkshire or charcoal iron. It thus combines the good properties of steel with the good properties of the best wrought-iron, and without the defects of the latter, as before referred to.

After such facts are known, it seems rather surprising that our railway engineers are not more alive to their own interest, when secured at such a small cost; yet so it is with almost everything that is new; for, unless some interest is taken in pushing it forward into notice, it takes a long time to overcome what, in this case, may truly be called the *vis inertiæ* of mankind.

These combined properties of elasticity, toughness, and brittleness are well worth the closest investigation of those philosophers and scientific men who are now engaged on the study of molecular physics, for, notwithstanding the great accumulation of useful facts, the unerring laws of nature by which they are all controlled and combined have not reached the workshop, so as to give certainty in the carrying out of mechanical operations in regard to such matters. The existing knowledge is more derived from practical facts than from the philosophy of the process.

To take a piece of old steel-spring, which has no doubt done its elastic work for many a year in some old clock; here it is, a grand combination of elasticity and brittleness. How wonderful must be the relationship between its molecules in submitting to be so roughly handled, to bear the drawing out of the particles on one side, and the pushing in of the particles on the other side as we fold it up, and then unfold it, and that this may go on every day for more than a hundred years, and yet there the molecules hold on with all their pristine vigour. It is only by trying to realise the motion among its molecules that we are able to appreciate its extraordinary properties, which too frequently pass unheeded. The explanation that the hardness, brittleness, and elasticity of the spring are due to the constraint put upon its particles by the sudden cooling, or partial liberation by the after-heating for reduction, is not satisfactory; they are also due to the presence of carbon as well as other causes. Iron without the carbon, or the metal copper, is not affected in the same manner; by heating the copper and plunging it in water it still retains its softness, and it is only by hammering or rolling, or otherwise rendering its particles rigid, that we can impart to it the character even of an imperfect spring.

Coming back to cast iron, it is also affected by oil-tempering in a similar manner, although in a less degree. An interesting experiment was made by Mr. Parsons. Two massive blocks were cut off the same piece of cast iron, and carefully turned to the same dimensions, each with a deep nick in the middle, so as to determine the breaking point. One of the pieces was made red-hot and dipped in oil, the other was left in its natural state; both were subjected to the equal blows of the steam hammer; the natural piece broke with three blows, the other did not break until the fifteenth blow, and, most remarkable of all, it was considerably bent, thus showing that tenacity and toughness were both combined. Such a result opens up a large field for future investigation, and will, no doubt, in time lead to important changes, more especially in the construction of cannon. Recent experiments point to many changes, and when men are able by some cheap process, such as the use of nitrate of soda, to take up the grosser impurities of cast iron, it will supersede wrought iron for many purposes. The Bessemer system is a first instalment. At present the interior of a gun is made of fine steel, tempered in oil, as before described, and is so far perfect, but the exterior is still made of wrought iron, either by building up in one mass or in successive layers, with each layer being put under a regulated but increasing tension. The latter affords the most perfect result of any system yet devised, but is accompanied with the great drawback that it is somewhat expensive.

What we require is a cheap exterior—a cast jacket to envelope the fine steel barrel—but which, at the same time, shall be as reliable as wrought-iron. A mixture of such cast metals as afford high tenacity combined with toughness in their natural state, and which, if submitted to the oil-tempering process, would probably be still further improved, and this will possibly lead to the utilisation of the old cast-iron guns, shot, and shell that are now in the service, at a comparative small cost for purification and re-casting. The recent result of experiments with the Heaton and other processes, all point in the direction now indicated.

There is another collateral subject which requires investigation in regard to the suitability of different oils for tempering alloys of iron and carbon, such as steel, in regard to their efficiency as depending on their constituents. The nitrogenous substances of hoofs and horns, which are now so successfully employed for converting the surface of wrought-iron into the steely condition termed case-hardened, probably owe a portion of their efficacy to the nitrogen as well as to the carbon. On the same principle, the probability is that the animal oils which contain nitrogen are the most effective in the oil-tempering process. Hitherto, vegetable oils have been employed, olive, and sea-cotton. It would be interesting to have reliable data in comparison with whale and neats'-foot oil, and likewise to determine whether the oil has any influence whatever beyond its power of conduction to a certain rate.

We shall now proceed to consider some of the leading principles which govern the processes of the very ancient art of founding, as they are affected, regulated, and controlled by the laws of nature. This is an art which has made great progress during the past fifty years. The controlling scientific laws are better understood and obeyed than formerly was the case, and in consequence much greater certainty now exists in regard to the production of sound castings, which is entirely due to increased knowledge, both theoretical and practical. Here we shall find ourselves in a region of clearer light, with a good natural reason for almost everything; and as my object at present has reference chiefly to the natural laws or principles, the technical terms of the workshop and the modes of manipulation, or even the apparatus of the founder's art, will be avoided as much as possible.

It may be stated at the outset, in a general way, that the modern founder invariably works from a model of the required article, and seldom or never originates the form in the foundry. From this model or pattern, the founder, by embedding it in the moulding material, obtains a correct form, or impression of the form, and when the copy is thus taken, and the model removed, the empty space is afterwards filled up with liquid metal, according to the laws of fluids. Even when mathematical forms are required, a species of model is used, as it is more convenient and economical to produce even such articles as cylinders or bells in this way. The founder, from choice, resorts to the principle of obtaining the required mathematical figure by transfer from a copy, as developed in a sort of lathe. With this lathe, together with a sweeping template or profile, the shape is given much on the same principle as a plasterer forms the cornice of a room. But all such art-arrangements are susceptible of endless modifications; the leading scientific principles of the art alone are unchangeable, although frequently unknown to the young founder, there being no schools or classes where such important knowledge can be acquired, and hence the wide sway of the rule-of-thumb. It is another general feature in the founding art that the founder, if possible, casts every article with the side which is most important undermost; this is done for two natural reasons, first, to have the benefit of the fluid pressure upon that side, and, in the next place, because any scoriæ that may pass into the mould, or gas bubbles that may happen to be generated and enclosed, shall, in virtue of their lightness, have the opportunity of rising to the top of the casting; hence it is that the upper side is frequently so imperfect when the skin is removed.

There is another general point of some importance, namely, that, as a rule, the best castings are seldom or never made in an open mould, because of the absence of fluid pressure, entire moulds are therefore employed. The pattern is thoroughly enveloped in the moulding material, and the mould is so constucted in parts that it can be taken asunder for the withdrawal of the pattern; the mould is afterwards reconstructed or closed, a small hole or holes being left in the upper part or otherwise to permit the entrance of the liquid metal, which flows in and fills up the space according to the laws of fluids. So far it is the same as water, for when metals such as iron or bronze are melted into the liquid state so as to be capable of flowing like water or other liquids, they are in this respect governed by the general laws of fluids, with pressure equal in every direction, and with pressure in proportion to their density; and when such liquid metal is poured into a mould of any form it finds its level, and fills up the vacant space. But, unlike water, plaster of Paris, or other cold liquids, the very high temperature of liquid iron or bronze involves other laws, and many other conditions are established in the mould which set all such appliances as are suitable for water at complete defiance.

The first effect of the molten metal is *to destroy the* substance of the mould, unless it is thoroughly refractory. The second immediate result is to generate gas from any decomposable substance in its vicinity, and suddenly to expand the air contained in the interior of the mould. The third contingency arises from the fluid pressure of such a dense liquid. A fourth set of conditions depends on the change due to contraction in cooling. The most of my remarks will have reference to some of these points as affecting the production of good sound castings.

Let us consider, in the first place, the nature of the substance of which the mould has to be composed, bearing in mind that the great essential property is that it must be thoroughly refractory, otherwise it would melt before the metal became a solid, and thus destroy the sharp form of the casting. Such substances are not so rare or limited as is generally supposed.

Until the middle of the 17th century, moulds for metal were made of clay, or clay with sand, forming a strong loam, afterwards well baked; but about the year 1700, the use of sand by itself was introduced into England from Holland, by Abraham Darby. Previously, pots and pans, and similar articles, had been cast in the old materials, but they were mostly so clumsy and so far inferior to those made by the Dutch in simple green sand, that every founder in the land was taken by surprise, and its introduction all over the country was immediate; and at the present time, the greater proportion of castings are made in that material. Under many modifications as regards the diversified mechanical details of art, the several reasons why sand met with such a hearty reception from practical men are manifest, so I shall enumerate them one by one. In the first place, pure sand is composed of one of the most refractory substances in nature, namely, silica; hence, if sand is really pure, it resists the action of the burning liquid most completely, as the heat of the metal has no chemical action upon it, and for this reason it can be used over and over again. But pure sand by itself has no adhesion, and cannot retain a definite form; this is its great defect. To be fit for the foundry it must be adhesive, and so it requires a small portion of some other substance, such as alumina or clay—say from three to five per cent. of clay has to be added to it; provided it is not found naturally, which it generally is in this country. The silica requires just as much of the clay property as will render it suitable for standing up firmly in the mould, and so capable of resisting the flow of the metal, and at the same time the addition of clay is a great disadvantage in another direction, as it tends to make the mould too close, thus preventing the free and thorough ventilation which is absolutely necessary, and hence the effect of the clay has to be counteracted by mixing the sand with coke or coal dust, or other similar substance, in order to render it more porous for ventilation. Sand, again, from the loose nature of its particles, has another valuable property, in that it can be easily rammed around, and made to conform to the irregularities of the pattern which is embedded amongst it, and, in addition, it may easily be pricked full of small holes with a fine vent wire, so as to allow the air, steam, and the various gases to escape from its interior mould, and also from the wall structure of sand comprising it, which always takes place as the metal enters escape the mould.

The leading feature of pure sand is the invaluable property of not generating gas. Any dirt amongst its particles, or the moisture on the mould's surface, or even in the sand, are instantly converted into gas, but the sand itself remains intact; and this, next to the refractory property (and from which it naturally results), is one of the three most important requirements of a moulding material, and is of the utmost value in the production of sound castings.

The next essential feature of a mould is ventilation, free and unimpeded; that the substance of which it is made shall, besides holding the metal without flinching, be so constructed that all the aeriform fluids which are generated shall find an instant and ready means of escape outwards, yet without interrupting the flow of metal inwards, so that the metal may be allowed to run quickly into its place, to fill up every crevice, to cool down without disturbance, and as the metal becomes a solid, that the sand or other substance shall be firm enough to bear the first crush of the expanding metallic ice at the moment of solidifying, and yet be so accommodating as to then permit the after-contraction from cooling. These are the natural requirements which the founder has to meet, and which sand fulfils in an eminent degree.

When the liquid iron or bronze runs into the mould, the great heat of the metal rarefies the air within fully three-fold, which must find an outlet at once; then the moisture which is contained in the sand is instantly decomposed into its constituent gases; the red-hot iron seizes hold of the oxygen, setting the hydrogen free; for this inflammable gas also, immediate escape must be provided; then the water in the exterior body of the mould is immediately afterwards converted into steam, and for this provision must also be made; then the coal-dust, which is mixed with the sand in order to render it open, is also generating gas; and all this is taking place within a fragile sand mould—indeed, so fragile that a child could break it up during the moment that it contains a liquid nearly seven times heavier than water, and with a temperature of between 2,000° and 3000°, and yet the mould is not blown to pieces. How is this possible? It arises simply from the porosity of the mould structure. It is constructed like a sieve for the aeriform fluids to find their way through, and yet close enough to prevent the iron from entering the pores, but yet sufficiently strong to bear the flow and the after ice-forming squeeze as the metal passes from the liquid into the solid condition.

We are all familiar with the circumstance that when an iron casting is taken out of the mould, its surface is found covered with a hard skin or crust, different to the iron within. This arises in a great measure from the silica and oxygen with which the iron has combined, the hydrogen having passed away, and may be seen to burn on the outside of the mould with a bluish flame. It is different with bronze casting, because bronze does not decompose the moisture of the mould; hence in the brass foundry steam predominates instead of the hydrogen gas of an iron foundry. Another interesting natural effect arises from the presence of coal-dust when mixed with the sand, from which a coke surface would necessarily be left on the exterior of the casting if not prevented, but the founder provides against this by dusting a pure film of charcoal-powder over the mould's surface. This, when the metal is poured, burns, and at the same time generates carbonic acid gas, which in small castings prevents actual contact between the iron and the sand or coal-dust, thus giving a smoother surface to the casting. Another singular effect is produced when the sand contains too much coal-dust, or indeed even charcoal. The effect is twofold. In the first place, it generates more gas than can conveniently escape by the usual channels; hence it finds its way into any out-of-the-way corner or other place within the mould where it can find a lodgment, and then the metal does not fill up the entire mould, as there cannot be two things in the same place at the same time. This law is inexorable, and the same result is seen even in the compression of cold lead bullets within dies; for unless the dies are ventilated to allow the air to pass away, the points of the bullets are wanting on the same principle.

The second effect which is frequently produced by the presence of too much coal-dust in the sand, is the formation of a coating of coke upon the metal, which may be compared to the residue of the coke in the retorts of the gas-making process, and which forms all over the surface of the casting. This hard incrustation is often difficult to cut through, as it may well be, seeing that it is the diamond-dust of the knife sharpener.

The third essential feature of a mould is a paradoxical combination of strength and weakness—that it shall be strong enough to bear the pressure of the dense fluid, and yet sufficiently weak to be crushed so as to admit the metal to contract freely in cooling. This apparent paradox is met by the founding art very cleverly. In forming the exterior mould, the sand is rammed into open iron cases with a force or firmness equal to the coming strain from the fluid pressure, namely, 15 lbs. per square inch for every five feet of vertical height of fluid; and the interior part of the mould that is to be crushed as the casting cools, say the core of a long pipe or other enclosure, is either made of a friable sand, or of some material that will crush, or it is partly constructed of a material that will catch fire, and burn to ashes. In such a core the three great conditions are—first strength, then ventilation, and lastly, that it may be crushed with impunity. In the case of a pipe core, the strong portion of such a core mould is an iron tube, perforated with small holes all over its surface for ventilation; this tube is enveloped in straw, in order to burn, over which is placed the refractory sand or loam, and coated with charcoal. Thus all the natural laws are complied with, as the gases generated in the earthy matter, and in the straw all find an outlet through the perforated pipe or core-barrel, which catches fire, or is lighted at the outer extremity, in order to promote ventilation. The iron case or box, which is commonly employed to hold the sand in forming a mould, is a great convenience, and facilitates the practical operation of founding immensely, but it is not an essential, except for strength, in cases where the casting would burst a sand-mould without such support. In making light castings, some founders dispense with the box during the casting, merely using it as an agent to enable the mould to be formed, after which the whole outer fabric is then unhinged; by this means one set of boxes will suffice for several scores of moulds, which are spread over the foundry floor, ready for the casting at the close of the day.

The natural laws that govern the founding art come into full play, even in casting the most simple forms. Take the case of a mould for a large plate, say, to be run into the required form in a mould formed on the floor of the foundry. To merely make such a receptacle for the metal in the sand, even if of the required dimensions, would be quite useless, as all the gas and steam generated under the liquid metal would have no way of escape, except by forcing an earthquake sort of passage through the liquid iron, or otherwise. It is therefore necessary, even in such a simple matter, to make the sand-bed thoroughly porous, either by horizontal pricking with a long wire, or by a substratum of coke or straw, or indeed, by any other means which will comply with the natural laws, so that all the aeriform fluids may pass quickly away from under the newly-cast plate, yet without disturbing the liquid metal, for that is the one great condition to secure, and the cheapest mode of doing it is the best. Here the founder shows his skill.

The contraction of metal in cooling, after it has become a solid, is governed by fixed laws, and each metal and every variety of a metal has its own law. That for bronze is nearly 1-60th of its length, while soft iron is considerably less, and varies from 1-90th to 1-120th, depending on the nature of the metal, and partly on the shape of the casting. Massive and even other castings are frequently larger than these rates would indicate, partly arising from the fluid pressure, bulging or otherwise enlarging the mould, or from the workman clumsily disturbing the mould in order to withdraw the model more easily, and the excessively hard iron has considerably greater contraction still. In that for chilled shells it is about double the ordinary amount of grey iron; hence the precise amount of contraction depends on many conditions.

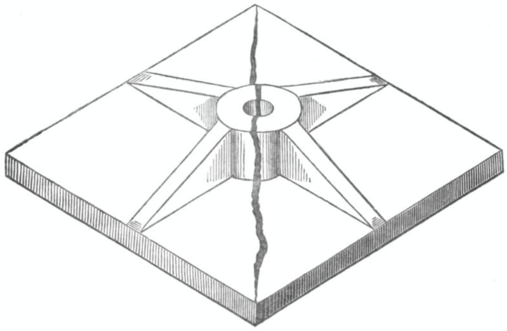
This law of contraction has to be looked at and considered from two different aspects; first, as regards the mould itself; and second, with reference to the casting. From the circumstance that metal contracts after solidifying, and that the casting is invariably smaller than the mould, unless the mould has expanded from the fluid pressure, or otherwise enlarged, the founder's model is made proportionately larger than the required castings so as to meet the case. Before going to work upon some difficult or unusual form of article, the skilful founder has carefully to study how the natural law is to be obeyed in several respects, as the casting will be a failure if he disobeys it in any particular. To take a simple case, supposing it to be a large pan, say fifteen feet long by eight feet broad, and a foot deep, and that it is determined to cast it with the bottom upwards, it is evident that with such a mould there will be an enormous quantity of aeriform fluid which will have to pass off from the interior core of the pan, and that the casting when cold will be nearly two inches shorter than when it was cast. How is such a case to be met? In many ways. One way is for the internal structure of the mould core to be composed chiefly of masses of coke, with a stratum of sand on the upper surface. This arrangement is simply to provide for ventilation; but to provide for the contraction between the sides and ends of the pan and the mass of coke there is interposed a thick matting of straw, the effect of which is that, when the metal flows into the mould, the heat gradually reaches the straw and sets it on fire, thus burning it, and giving freedom for the natural contraction which follows immediately afterwards. There is also to be provided a free passage from the great interior core to the exterior of the mould, so as to give the utmost freedom for the gases to escape. With such a broad casting, exposing so much surface, the total fluid pressure is enormous, the whole of which is exerted in floating the upper or covering portion of the mould, as the pressure is equal in every direction. In order to prevent this cover or upper part of the mould from rising, a proportionate weight has to be laid upon it. In the best-ordered foundries the roof is adapted to take the pressure; it is so arranged that adjustable pillars can be introduced between the mould-cover and the heavy roof, to which the fluid pressure of the metal is transferred at the moment of casting, thus avoiding the labour of putting on and removing the weights.

As an interesting example of the effect of contraction, let us take the familiar case of a heavy fly-wheel with a massive rim and centre, but with arms of the usual proportion. It is clear that, with such dissimilar dimensions, if no peculiar means are provided, the cooling and contraction of the several parts of the wheel would proceed at very different rates as regards time. First, the arms, on account of their slimness and consequent lightness, would be the first to cool and to shorten. Now, what will necessarily happen if such is the case (and which too often does happen when the contraction laws are disregarded), is, either the arms in cooling will draw themselves away from the outer rim by simple fracture, or, as another alternative, they will actually stretch between the rim and centre, and thus remain permanently longer than the normal length. If the former happens, then the wheel is of necessity destroyed; if the latter, which is the more likely, what will then happen? Why, the heavy rim of the wheel will be broken before it is cold by the abnormally extended arms preventing it from obeying the natural law. The law is inexorable, and demands that the wheel, or any other form of casting, shall cool uniformly in all its parts, no matter how it is to be accomplished—that the founder must find out, but it must be done, either by using means to keep the lighter parts hot, or else by hastening the cooling of the more massive parts, so that all may contract at the same rate, and so preserve the wheel intact, and the whole structure in a condition of equilibrium. This subject demands the closest study of the young founder who intends being master of his business, as it involves a principle that governs the soundness of many other forms of casting.

It is on account of these several contingencies that many large fly-wheels are made in separate parts and put together afterwards; or the law may be evaded, and is often evaded, by first making the spokes separately, either of cast or wrought-iron, then laying these spokes in the wheel-mould, and first casting the rim by itself, it being arranged to embrace the outer ends of the spokes, which, as it cools and contracts, gradually pushes the spokes inwards. When the rim has taken its normal dimension, then the centre part is cast around the inner ends of the spokes; thus the whole structure is approximately in equilibrium, and such wheels—but more especially those built-up afterwards—are more reliable to withstand the effect of jar and centrifugal force than when cast in a single piece at one casting, even when the utmost care has been taken to obtain uniform cooling.

Still more interesting is the case of massive solid castings, apparently of great strength, but afterwards breaking of their own accord. A case of spontaneous fracture occurred the other day. The article was in the form of a large massive plate, with an embossed part in the centre, and having strong radial ribs, as shown in the diagram (Fig. 18). It was duly delivered by the maker entire, but after lying for a day or two it suddenly split through the middle to within a few inches of the outer edges, showing unmistakably that the crystallisation was not previously in a state of rest or equilibrium. On inquiry it was found that the cooling of the mass had been hastened. The effect here produced was the reverse of the fly-wheel; the outer edge of the plate was of necessity the first part to cool and contract, but the contraction was prevented by the bulk of the still hot and expanded interior, hence the iron composing the outside had either to stretch or give way by tearing open. As it so happened, in this instance it stretched. When the interior metal became cooled it also contracted, and for

FIG. 18.



a time kept up its continuity with the outside, each resisting the natural law that regulated the other; the outside, from having been previously stretched, was determinedly unwilling to go inwards. The struggle for separation between the two had been going on for several days, and during the railway journey. At length peace was restored by the mutual parting, which at once destroyed their future usefulness for the intended purpose.

Referring again to the subject of mould-ventilation, it will have been observed how very much the process of casting would be simplified if the formation of gas could be entirely prevented. It will also be remembered how very much the molecular conditions of the metal are affected by the rate of cooling, the best result being obtained by slow cooling, thus giving time for that state or condition of crystallisation which gives elasticity and ductility, constituting toughness. Coupling these two questions will enable us to understand the principles of various other systems of moulding which have been resorted to by various founders in order to meet them. This is another point that the young founder should study closely.

It will be evident, from what has been said, if the surface of the sand-mould is thoroughly dried, either by fire or otherwise, before the liquid metal is poured in, that consequently there will not be so much decomposition of water, and therefore a less quantity of hydrogen gas to get rid of. Carrying this a step further, if the sand has had given to it an additional per-centage of clay in its composition, so that it will bear to be still more thoroughly baked, yet without losing coherence, by such a process a large share of the other gases will also be eliminated, and, besides that, the metal will have to enter a warm instead of a cold mould, which will of necessity, and to a considerable extent, protract its rate of cooling; or, if a still stronger mould is prepared by using loam instead of sand, that is to say, sand mixed with a still larger proportion of clay, and then thoroughly baked or burned, the two conditions will still further be met. Hence it is that for guns and other important castings, more especially where the expense of moulding is formidable, and goodness of quality indispensable, some one or other of these modifications is now generally resorted to, and either system is an improvement on the other, by thus affording a corresponding increase of quality in the casting, but, like most good things, the cost of production is increased.

The Americans have carried the art still further in these respects. Any gas emanating from the sides of the hard mould must enter the casting—possibly it may rise to the surface, but often (and more especially if the metal is as cold as can be poured, which is often desirable) it does not, and however carefully the loam or the baked sand may have been prepared, still dirt may exist in its composition, which will develop gas from the high temperature of the liquid metal even in its coldest liquid state, and so form vacant bubble-holes or specks in the casting.

These considerations have led to the introduction of two other systems which are employed in America. One of these was introduced by the late Mr. Babbit, of Boston, the other by Mr. Ames, of Chickopee, also in Massachusetts. For the former system, instead of sand or loam, old worn-out fire-bricks are selected, more especially those which have not changed their pale colour in the furnace of which they originally formed a part (those with any red in them are rejected, as indicating the presence of iron or other impurity). These old fire-bricks are then ground to a fine powder in a mill, and then as much pure pipe-clay water is added to the brick-dust as will give sufficient coherence to enable it to form the mould structure; this mould, after baking, is then painted over with a creamy liquid made of the same materials, and is then burned to redness, and the metal is poured into the mould while it is in that condition. By the other system, the material used is kaolin or decomposed granite, which is taken all the way from England, and is treated precisely in the same manner as the brickdust. By this means all the essential conditions are obtained in the highest degree, and, from the absence of porosity in such moulds, there is less waste of such valuable metals as bronze and the like, for which the more expensive materials are chiefly employed.

To show the earnestness of our Transatlantic competitors, there is yet another of their refinements in the art of casting guns which has not yet been practised in this country, so far as I am aware. It is the process of cooling a casting of such a large liquid mass as a gun or a mortar more directly from the interior, that is to say, the mass of metal, after it has been cast, is cooled from the core instead of from the outside. The object of such an apparently dangerous experiment is partly explained by what has been already said in reference to the fractured plate, which failed by the cooling process having been hastened from the outside; for when a mass cools from the outside, that part in cooling and contracting will necessarily have to stretch upon the hot and still expanded metal within, then another layer upon that which is within it again, and so on until the entire mass is cooled down to the temperature of the atmosphere, each layer endeavouring to pull itself away from that which surrounds it, hence the outer layers are not called upon to perform their proper share of the work at the moment of explosion; but by cooling a gun or mortar gently from the inside, either with a current of cold air or with water circulation, the conditions are entirely reversed, and each layer, as it cools, tends to grip the layer within it faster and firmer, thus approximately obtaining the advantages secured by building up wrought-iron guns on the system so successfully introduced by Sir William Armstrong, with the inner tube held fast in the grip of the second, and the second in the grip of the third, thus giving the whole mass some work to perform by the initial tension on the layers. From recent accounts it would appear that the rate of cooling from the inside, as adopted by the Americans, has been too rapid, thus throwing the mass into a condition ready for spontaneous fracture, in the opposite direction to the broken plate previously referred to, showing that the founder has to study the natural conditions with extreme care; but time and study will bring out the proper course to pursue, in order to arrive at the best result, for it is generally by failure that we reach perfection.

From the several references made to American founders, the great success which has attended the American gun recently brought to this country need excite no surprise. The close attention paid to the natural laws, in every detail of the founding art, by the American founders, is worthy of the highest praise.

With regard to the question of modifying iron, it has been already stated that when castings are required to be particularly solid or dense, they are generally made with what is termed a "dead head," so as to increase the fluid pressure on the casting; and, as a rule, where density or rather closeness of structure is particularly wanted, the higher that the "dead head" is carried so much the better in that respect. And, still further to improve these conditions, it is found that by keeping the liquid metal in a state of gentle agitation so long as it remains a liquid, an advantage is gained thereby. This is accomplished by the use of an iron rod, which is worked up and down like a pump-rod, and then, from time to time, as the metal condenses and subsides, the empty mould is filled up by pouring in fresh metal again and again. The increasing condensation thus proceeds, and considerable benefit is thereby obtained in regard to the tenacity and general density of the casting, and more especially in the soundness of the interior.

The foregoing remarks apply more especially to iron castings. The casting of other metals differs in some respects; it is found advantageous, for example, to hasten, or rather not to delay, the cooling of bronze guns, at least not to protract the liquid condition longer than is necessary, as there is then a tendency for the tin to separate from the copper. When such groups of tin aggregate, the quality of the metal is much inferior to those other portions where the alloy is in the proper condition and mixture as intended.

This subject would be incomplete without a word of reference to the question of quality of iron or bronze castings, as depending on the principles of the melting processes. There are three courses open to the founder, and his selection depends on the object to be attained. These several systems are governed by natural principles, chiefly dependent on contact and contamination with fuel.

The best course to follow of all modes of melting, for casting small articles where goodness of quality is paramount, and where the expense is not a consideration, is the pot or crucible system, which is now generally employed for the trinket class of articles, or when an extremely liquid iron is necessary. The iron selected for such purposes is not only rich in uncombined carbon, but it is much preferred with an addition of phosphorus as well, which is mostly found in the iron made from the bog ores, and causes it to run like water. The advantage of the pot or crucible system is this, that the metal being melted in a covered pot, which is placed in the furnace, the metal by this means is not exposed to the evil contamination of the surrounding fuel. The great and only objection to the crucible system is the expense, as it requires some 15 cwt. of fuel per ton of iron melted, and hence it is seldom or never employed for the common or heavier class of iron castings, which will not bear the cost, but is frequently resorted to for the class of castings made of the finer kinds of cast-steel and bronze.

The system of melting iron which is mostly resorted to in engineering establishments is the vertical or upright furnace arrangement, usually termed a "cupola," in which the iron and fuel, with flux to suit, are thrown in together at the top of the furnace promiscuously. A blast of wind is forced into the burning fuel at some distance from the bottom, and as the metal melts it runs down in rivulets or large drops, and sinks to the bottom of the furnace in virtue of its density, and is there collected in what may, in point of fact, be considered as a crucible, with the fuel floating on its surface. There it remains until there is a sufficient quantity for the intended casting, when it is run out into a dam or ladle. The opening is made by tapping a hole at the bottom of the furnace, and is afterwards plugged up with clay.

The chief advantage derived from this method is the economy in fuel, which in round numbers may be stated as varying from 1¼ cwt. to 2 cwts. of coke to melt a ton of metal. The great defect is that due to the intimate acquaintanceship formed with bad company, namely, between the sulphur or pyrites in the fuel and the exposed metal as it filters downwards; it thus becomes frequently deteriorated to a great extent, especially if there are many impurities in the fuel, and, in consequence, the castings made in this way are, as a rule, not so strong as those made by either of the other two methods.

The cupola or upright furnace, besides being economical, has also the recommendation of bringing down the metal at a high temperature, which, for many purposes requiring extreme fluidity, is highly important (and with truth it may be said that the great majority of castings are not required to be particularly strong). Hence for all ornamental work, and for light machinery castings in general, the cupola is the usual means employed by the modern founder, and was a grand invention, which has saved millions sterling to the world, a virtue that covers many disadvantages.

When the highest degree of goodness is aimed at, for heavy castings such as guns, an entirely different system is resorted to, which is termed the air furnace, in which the iron is melted by a flame, proceeding from another part of what is called the reverberatory furnace, in which the flame from a fire strikes the roof first, and then re-acts on the crucible; hence the metal does not come so directly into contact with the fuel as it does in the cupola; and, even when the metal is actually melted, any impurities existing in the flame merely play upon the metallic surface, while at the same time it slightly tends to purify by its oxidising influence, for it is found that the metal thus subjected to the influence of the flame for a time is really improved by the action, and, taken as a whole, the air-furnace makes the strongest castings, even with the same sorts of iron. The chief disadvantage is the cost, as it requires four times as much fuel as the cupola, and about the half of that required by the crucible system; still, for a responsible duty, it is worth while paying a little extra price, it being so much more reliable.

The founder, in selecting a mode of melting for guns, or any similar class of articles, invariably chooses the air-furnace; he is also very particular in the selection and sorting of his mixtures of iron. It is seldom that less than ten varieties are selected, each the best of the sort. In this country, the strong cold-blast irons of Wales mostly predominate, but not entirely so, for if the strongest sorts were entirely selected and used, it might seem at first sight to be not very far wrong, but it would be a complete failure, notwithstanding; the gun would fail from the property of brittleness, or rather from the want of ductility and elasticity. The requisite conditions are slightly paradoxical, but it is found that a mixing of the stronger sorts with the softer and more ductile sorts gives the best result, by a kind of compromise. This knowledge is founded on the result of former dearly-bought experience, successes, and failures, spread over centuries.

Having thus endeavoured to refer to some of the leading natural principles upon which the art-processes of casting are founded, I had intended, when the title was given to my lecture, to have referred also to the numerous natural laws of the equally important smithing art, but have found it impossible to do so with any degree of justice, within the limits of a single lecture.

Taking a great interest in the prosperity of our national manufactures, in competition with that of other nations, it would seem to me that we require to teach our young men the principles of every subject in connection with practical art, rather than the apparatus or the machinery, which can more easily be acquired in the workshop, and very much better than in the school. We do not all require to know the mechanical details of all the branches of mechanical art, but all who are connected with applied mechanics should know the natural principles thoroughly, which in themselves, when understood, are extremely simple and even fascinating, and such teaching will render the varied machinery more easily understood by those whose business it is to know, and equally so by those who derive pleasure from the examination of technical subjects.

To take, for example, the case of some of our textile manufactures. To any one not acquainted with a cotton-mill, the stranger, on entering, is at first appalled at the mystery of whirling mechanism which he sees around him, and is perfectly bewildered with it, as a something that no one could understand; but if anyone will take the trouble to explain the three simple objects to be accomplished, and the leading mechanical principles that are employed to effect the object, then it becomes as simple as *a*, *b*, *c*.

It is not necessary that every student in applied mechanics should know the *minutiæ* of every detail of the art of cotting spinning, but he should know the few leading principles upon which the manufacture is carried out. The cotton comes to England in bales, in a state of hard clotted masses of wool. The three first classes of machines are to render these lumps soft, open, and flocculent, which is accomplished by repeated beating, opening up, and spreading out. Then comes a second series of machines, first to card or comb the individual fibres, so that they may approximately be laid side by side, and then by a repetition of drawing out the fibre, and then doubling and drawing out again repeated many times by means of rollers moving at different velocities, the fibres are at length laid parallel with each other in a fine filament; then comes the third class of machines for still further drawing out the filament to the required fineness, and then the final imparting to it of a slight amount of twist, so that the element of friction may be introduced among the fibre, in order to give the thread of yarn strength. After this comes the action of the loom for weaving it into cloth, which is self-apparent.

It seems to me that, in our mechanical teaching, we make too much of the mechanism, which may be varied indefinitely, and too little of the natural principle. The consequence is that, by far too much, we copy each other's arrangements of mechanism; whereas, if we were taught the natural and mathematical principles, and shown that they could be applied in many different ways, setting each one to find his own mechanism, and letting it be considered wrong for a man to copy other men's mechanical forms and arrangements within a reasonable period, by so doing a great change would soon be experienced if our young men were sent out to explore in the boundless field of mechanism which lies open to all, instead of repeating the forms and arrangements that have been adopted by others. The design of a steam engine, or any other machine, so far as it depends on men, should in honour, for a reasonable period, be as sacred as a book or a picture. The natural law which the machine employs or applies can belong to no one in particular, and the machine can be constructed in thousands of different forms and arrangements of the mechanical alphabet, that is to say, if it is of sufficient importance.

The prominent consideration of the natural principles as thus associated with and determining working mechanism would impart a dignity to the mechanical art. For some reason, not easy to trace, the notion has arisen, that art-working is in some way antagonistic to theoretic thinking; my remarks on the founding art serve to show that, in that department at least, there is no ground for such a conclusion. The founder's practice, as derived from former experience of success or failure, is just as true philosophy as the inductive theory of the thinker. The working philosopher may be more conservative, and not so speculative; he has learned from financial experience not to venture too hurriedly nor too far out of the beaten track, until the field beyond has to some extent been explored and made certain. Practical men are frequently spoken of as if they had a contempt for theory. So far as my observation extends, such is not the case. On the contrary, where no money interest intervenes, there is generally evinced a craving for correct knowledge, so as to accomplish the object at the least expense. On the other hand, the men of learning who, from their pursuits, are more acquainted with theory than practice, are too frequently underrated by practical men; this is an equally great mistake; if properly understood, the tendency should lie the other way. There is no sound practice without true principles, come from where they may; and practical men are immensely indebted to those philosophers and men of science who, frequently without remuneration, take the trouble to investigate first principles and give them to the world freely and fully, whose labours have been, and are now, of incalculable value in reducing facts to order, and giving us simple yet comprehensive formulæ for the guidance of construction, and who investigate and lay open the mysterious laws of heat, and other natural agencies, and make plain to the more occupied and plodding busy workers the wonderful phenomena of the innumerable laws of nature. It will thus be seen that applied mechanics is a large field to cultivate, and requires many workers, and affords an abundant scope for all, both for head-workers and hand-workers, and the best result will be arrived at by each and all, theoretical and practical, or both combined, trying to do his own part well; and just as it is in the commercial or trade competition of two great rival manufactories, with each individual selected and thoroughly well trained to perform his allotted part, so it is the same with the united workshops of a country such as Great Britain in its competition with some of the foreign nations, who are now stealing a march upon us by training their school-boys and future workmen in the knowledge of first principles. We must, as a nation, do the same, or otherwise our workmen will be placed at such a disadvantage as no other national characteristics or amount of hard working can long withstand; for, next to an intimate individual acquaintance with the principles on which their own immediate branch of craft duties are founded (that being in every case the first consideration, for those who neglect themselves in this respect, will soon begin to find the world going past them, even in their own speciality), the addition of such simple natural knowledge as I am recommending will not only increase the usefulness of our young men, even in their own branch, but the extra pleasure which it will afford through life will be a rich reward, and help to raise our workmen above the grovelling and expensive habits in which so many are now found to indulge from the want of having their minds otherwise occupied, and will help to keep us right in the collateral questions of political economy, as connected with trade, manufacture, and commerce.

Proceedings of Institutions.

EXAMINATION PAPERS, 1869.

(*Continued from page 720.*)

The following are the Examination Papers set in the various subjects at the Final Examination held in April last:—

MENSURATION.

THREE HOURS ALLOWED.

1. Find the area in yards, feet, and inches of a room which is 17 ft. 3in. long, and 14 ft. 7 in. wide; and the cost of flooring it at 2s. 6d. a square foot.

2. Find the area of a triangle whose sides are 28, 45, and 53.

3. Show that the area of a four-sided figure of which two sides are parallel = base × average height.

The sides of a quadrilateral are 3, 4, 5 and 6, 3 and 6 being parallel to one another: find its area.

4. A wall measures 94 ft. 6in. in length, and 12 ft. 9in. in height, and is 2½ bricks thick: how many square rods of brickwork does it contain?

5. What will be the expense of lining a cistern, 5 ft. 6 in. long, 3 ft. 4 in. wide, and 1 ft. 2 in. deep, with sheet lead of 12 lbs. to the square foot, the lead costing £2 per cwt.?

6. The areas of two concentric circles are 154 yards and 68 yards 4 feet: find the breadth of the annulus.

7. A semicircular protractor is 3 inches in diameter, and the rim (curved and straight) is half-an-inch wide: find the area of the hollow part.

8. The areas of three sides of a rectangular block of wood are 3 ft. 128 in., 18 ft. 48 in. and 6 ft. 60 in.: find its volume.

9. Find the diameter and height of the least circular cylinder from which the block in the preceding question can be cut.

10. Find the surface and solid content of a regular tetrahedron whose edge is ten feet, in feet and inches.

11. A circular vessel which is 7 inches in diameter at the top, and 6 inches at the bottom, is made to hold a pint: what must be its depth?

12. A circular plate, of an inch in thickness and a foot in diameter, is formed into a sphere: find its diameter.

13. Prove that the surface of a sphere is equal to $4\pi\,(\text{rad.})^2$

PLANE TRIGONOMETRY.

THREE HOURS ALLOWED.

1. A B C D is a quadrilateral inscribed in a circle. Show that $AC \sin. A = BD \sin. B$.

2. Find cos. A in terms of the sides of A B C, and thence prove that, if $2s = a + b + c$,

$$\tan.\ \frac{A}{2} = \sqrt{\frac{(s-b)\ (s-c)}{s\,(s-a)}}.$$

3. If $\tan. A = -(2 + \sqrt{3})$ prove that $A = \frac{\pi}{12}(12n + 7)$.

4. Prove that (1). $\text{Cos.}\ (A + B) = \cos. A \cos. B - \sin. A \sin. B$. (2.) $\text{Sin.}\ (A + B) + \cos.\ (A - B) = 2 \cos. \left(\frac{\pi}{4} - A\right). \cos. \left(\frac{\pi}{4} - B\right)$.

5. The perpendicular from the angle of a triangle on the base is an harmonic mean between the radii of the adjacent escribed circles.

6. Given $b = 15$, $a = 10$, $\log. \sin. A = 9{\cdot}5228787$, $\log. 2 = {\cdot}3010300$, $\log. 3 = {\cdot}4771213$, find B.

7. Show that $\tan. A = \dfrac{\sin. A + \sin. 2A}{1 + \cos. A + \cos. 2A}$

8. And $(\cot. A)^2 - (\tan. A)^2 = 4\cot. 2A \cdot \text{cosec.}\ 2A$

9. Find x when $(\tan. x)^3 = \tan.\ (x - a)$

10. A B C is a triangle inscribed in a circle, radius R; A D and B E are perpendiculars from A and B on the opposite sides, intersecting in F; prove that $AF = 2R \cos. A$.

11. If the sides of a triangle be 7, 13, and 8 feet respectively, find the greatest angle.

12. If $(\text{cosec.}\ A)^2 = m \tan. A$; and $(\sec. A)^2 = n \cot. A$, then, $(\sqrt{m} + \sqrt{n})^4 = (mn)^3$

13. One angle of a triangle is 60°, the sides including it are in the ratio of 3 : 2, show that the tangents of the other angles are $3\sqrt{3}$ and $\frac{1}{2}\sqrt{3}$

14. Find the angles between 0° and 360° which satisfy (1.) $\text{Tan.}\ 2A = 1$; (2.) $\text{Cos.}\ A = 1 + \cos. 2A$

15. If $\cos. 7A + 7\cos. A = 0$; then shall $\cos. A = \sqrt{\dfrac{7 + \sqrt{-7}}{2\sqrt{2}}}$

16. If θ be be a very small angle, $3\theta = 2(\sin. 2\theta - \theta) + (\tan. 2\theta - \theta)$ nearly.

CONIC SECTIONS.

THREE HOURS ALLOWED.

Section I.—Geometrical Conics.

1. A focus and a directrix being given, define a conic and show that your definition leads to three species of curves, of which one is closed, the second is open in one direction, and the third is open in both directions.

2. Prove that the subnormal of a parabola is equal to half the latus rectum.

3. Tangents drawn to a parabola from any point in the directrix are at right angles to each other. Prove this.

4. Show that the area contained between a parabola and a chord parallel to the tangent at the vertex is two-thirds of the rectangle contained by the chord and the perpendicular on it from the vertex.

5. Assuming an ellipse to be defined, as in question 1, show that there are two foci; and that the sum of the distances of any point on the ellipse from them is constant.

6. Prove that in the ellipse

1. $SY \times S'Y' = BC^2$
2. $CP^2 + CD^2 = CA^2 + CB^2$.

7. Prove that in the ellipse and in the hyperbola the middle points of parallel chords lie in a straight line. Also prove the theorem projectively.

8. Define asymptotes; and prove that the portion of any tangent to a hyperbola intercepted between the asymptotes is bisected at the point of contact.

9. How far is it true that a straight line which meets a conic in one point also meets it in a second point, and never meets it in more than two points?

10. What are the relative positions of a circle, a parabola, and a point, so that the point being the centre of projection, the circle may be projected into a parabola?

Section II.—Analytical Conics.

11. Explain the method of determining position and loci by means of rectangular and polar co-ordinates respectively.

12. Show that the equation of a straight line is an equation of the first degree in terms of x and y. Find the length of the perpendicular from (a, b) on the straight line $x \cos. \alpha + y \sin. \alpha - p = 0$.

13. Define a tangent to a circle, and the length of the tangent from (a, b) to the circle whose equation is $x^2 + y^2 = c^2$; what is the geometrical meaning of the result when (a, b) is within the circle?

14. Prove analytically the theorems given in questions 2, 3, 5, 7, 8 of the preceding sections.

15. Show analytically that the angle between the focal radii vectores is bisected by the normal internally in the ellipse, and externally in the hyperbola.

16. Prove that generally three normals can be drawn to a parabola from given points.

(*To be continued.*)

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, 1869.

The thirty-ninth annual meeting of this association will commence on Wednesday next, August 18th, at Exeter, under the presidency of George G. Stokes, Esq., M.A., D.C.L., Sec. R.S., Lucasian Professor of Mathematics in the University of Cambridge.

The Executive Committee at Exeter will elect new members and associates, on the usual conditions, and after August 13th, personal application for tickets must be made at the reception-room, Exeter, which will be opened on Monday, August 16th.

Gentlemen who have in any former year been admitted members of the association may, on this occasion, renew their membership, without being called upon for arrears, on payment of £1.

In the reception-room there will be an office for supplying information regarding the proceedings of the meeting. The "Journal," containing announcements of the arrangements for each day, will be laid on the table on Wednesday, August 18th, and the following mornings, at 8 a.m., for gratuitous distribution. Lists of members present will be issued as soon as possible after the commencement of the meeting, and will be placed in the same room for distribution. The published volumes of the British Association will be sold in this room, to members and associates only, at the reduced prices appointed by the Council. The members' ticket will contain a map of Exeter, and particulars as to the rooms appointed for sectional and other meetings.

For the convenience of members and associates, a branch post-office (which will be available also for communication between members attending the meeting) will be opened in the reception-room.

Members and associates may obtain information about local arrangements and facilities afforded by the railway companies, on application to the local secretaries at Exeter.

The first meeting of the General Committee will be held on Wednesday, August 18th, at 1 p.m., for the election of sectional officers, and the dispatch of business usually brought before that body. The General Committee will meet again on Monday, August 23rd, at 3 p.m., for the purpose of deciding on the place of meeting in 1870. The concluding meeting of this Committee will be held on Wednesday, August 25th, at 1 p.m., when the report of the Committee of Recommendations will be received.

The first General Meeting will be held in the Victoria Hall, on Wednesday, August 18th, at 8 p.m. precisely, when Joseph Dalton Hooker, M.D., D.C.L., F.R.S., &c., will resign the chair, and Professor Stokes, M.A., D.C.L., Sec. R.S., &c., will assume the presidency, and deliver an Address. On Thursday evening, Aug. 19, at 8 p.m., in the Albert Memorial Museum, a *soirée*. On Friday evening, Aug. 20, at 8.30 p.m., in the Victoria Hall, a Discourse will be delivered by Professor Phillips, LL.D., D.C.L., F.R.S., F.G.S., &c., on "Vesuvius." On Monday evening, Aug. 23, at 8.30 p.m., in the Victoria Hall, a discourse will be delivered by J. Norman Lockyer, Esq., F.R.S., F.R.A.S., on "The Sun." On Tuesday evening, Aug. 24, at 8 p.m., in the Albert Memorial Museum, a *soirée*. On Wednesday, Aug. 25, the concluding General Meeting will be held in the Victoria Hall, at 4.30 p.m.

The sections are as follows:—

A.—Mathematical and Physical Science.—(In the Grammar School.)—President—Professor J. J. Sylvester, M.A., LL.D., F.R.S. Vice-Presidents—Professor J. C. Adams, M.A., D.C.L., F.R.S.; William R. Grove, M.A., F.R.S. Secretaries—Professor G. C. Foster, M.A., F.R.S.; R. B. Hayward, M.A.; W. K. Clifford, B.A.

B.—Chemical Science.—(In the Albert Museum.)—President—Dr. H. Debus, F.R.S., F.C.S. Vice-Presidents—Professor W. Odling, F.R.S., F.C.S.; Professor A. W. Williamson, F.R.S., Pres. C.S. Secretaries—Professor A. Crum Brown, F.R.S.E., F.C.S.; Dr. W. J. Russell, F.C.S.; Dr. Atkinson.

C.—Geology.—(In the Temperance Hall, Friars'-walk.)—President—Professor R. Harkness, F.R.S., F.G.S. Vice-President—R. A. C. Godwin-Austen, F.R.S., F.G.S. Secretaries—W. Pengelly, F.R.S., F.G.S.; W. Boyd Dawkins, F.R.S., F.G.S.; Rev. H. H. Winwood, M.A., F.G.S.

D.—Biology.—(In the Episcopal Schools.)—President—George Busk, F.R.S., F.L.S., F.G.S. Vice-Presidents—C. Spence Bate, F.R.S., F.L.S.; Edward B. Tylor. Secretaries—Henry T. Stainton, F.R.S., F.L.S., F.G.S.; Professor Michael Foster, M.D.; Rev. H. B. Tristram, M.A., LL.D., F.R.S.; E. Ray Lankester.

E.—Geography.—(In the Victoria Hall.)—President—Sir Bartle Frere, F.R.G.S. Vice-Presidents—Sir G. Grey; A. G. Findlay, F.R.G.S. Secretaries—H. W. Bates, Assist. Sec. R.G.S.; Clements R. Markham, F.R.G.S.; R. H. Major, F.S.A., F.R.G.S.; J. H. Thomas, F.R.G.S.

F.—Economic Science and Statistics.—(In the Athenæum.)—President—The Right Hon. Sir Stafford H. Northcote, Bart., C.B., M.P. Vice-Presidents—Colonel W. H. Sykes, M.P., F.R.S.; T. D. Acland, M.A., D.C.L., M.P. Secretaries—Edmund Macrory, M.A.; Frederick Purdy, F.S.S.

G.—Mechanical Science.—(In St. John's Hospital.) President—C. W. Siemens, F.R.S. Vice-Presidents—G. P. Bidder, C.E.; C. Vignoles, C.E., F.R.S., F.R.A.S. Secretaries—P. Le Neve Foster, M.A.; W. Smith, C.E.

The different sections will assemble in the rooms appointed for them, for the reading and discussion of reports and other communications, on Thursday, August 19th; Friday, August 20th; Saturday, August 21st; Monday, August 23rd; and Tuesday, August 24th, at 11 a.m. precisely.

The Committees, consisting of officers of sections and members conversant with the several branches of science selected by them, will meet in rooms adjacent to the section rooms, at 2 p.m., on Wednesday, August 18th, and at 10 a.m. precisely, on the other days.

SCIENCE AND ART AND NATIONAL EDUCATION.

Among the notices of motion intended to be brought on in the next session of Parliament, there is the following very important one, to which the attention of the Institutions in Union with the Society and the friends of national education should be called:—

Dr. Lyon Playfair—"National Education—That, in any scheme for national education, the Revised Code should not limit State aid in elementary schools to the subjects of reading, writing, and arithmetic, but should also offer inducements for the study of such subjects of elementary science and art as bear upon the occupations of the people, and tend to the advancement of industry."

LECTURES ON THE MODE OF TEACHING SCIENCE.

Two courses of lectures have lately been delivered, the one in the lecture theatre of the Royal School of Mines, Jermyn-street, and the other in the new lecture theatre at South Kensington, which will have a most important result on the future teaching in the science schools and classes throughout the United Kingdom.

The lectures were addressed exclusively to teachers engaged, or those about to engage themselves, in giving instruction in animal physiology or experimental physics; and, by a liberal grant for travelling and personal allowance from the Science and Art Department, about two hundred teachers were collected from all parts of England, Scotland, and Ireland, in order to take advantage of the opportunity thus afforded.

The origin of the lectures was due to Prof. Huxley, to whom the public is indebted for many other valuable and practical suggestions. This gentleman has been the examiner of the Science and Art Department in animal physiology and zoology ever since the commencement, in 1861, of the present system of science examinations, and in a report to the Committee of Council on Education, dated 9th February, 1869, he made the following remarks:—"The examinations in physiology which I have conducted for the Science and Art Department have exhibited a great increase in the number of candidates, and a very considerable improvement in the quality of their knowledge during the last few years. It appears to me, however, that there is still far too much of mere bookwork; and as the special value of science, as an instrument of education, depends upon its bringing the mind into direct contact with the facts of nature, I think it is highly desirable that teachers of physiology should be made aware of the necessity of so doing, and be instructed in the methods by which, with very common and easily-acquired materials, they may bring the most important and fundamental facts of physiology under the direct apprehension of their pupils. I propose, therefore, that a course of (say) six lectures should be given on the "Method of Teaching Physiology," and that these lectures should be made accessible to all science teachers who may wish to profit by them." The Lords of the Committee of Council on Education at once adopted Prof. Huxley's valuable suggestion, and passed a minute on the 11th March directing that two such courses should be given, the one on animal physiology, and the other on light, during the summer months, after the science classes had broken up.

To all teachers engaged under the Department in these subjects, and also to those who are qualified to teach, and who commence classes at once, second-class railway fare to and from their homes, and £5 for each one's expenses while in London, was offered on condition of their attending regularly. To such an offer it is hardly necessary to state that all who could possibly leave their occupations attended, and took advantage of the lectures and the opportunity of spending a pleasant fortnight in London.

The lectures on "Light" commenced on the evening of the 28th June, and the apparatus used in showing the phenomenon was chiefly that prepared by Dr. Tyndall. That gentleman was not able to deliver the lectures himself, but deputed Dr. Guthrie, who spared no pains or trouble in endeavouring to show the various phenomena, and in illustrating the method of demonstrating them to a class.

Professor Huxley, in introducing Dr. Michael Foster as the lecturer, delivered an inaugural address to the course " On the Method of Teaching Animal Physiology." He pointed out the motives which had led him to make this suggestion of delivering such a course, and sketched out a short history of what has been gradually done since 1861 for the assistance of teachers, in enabling them to know what to teach. He stated that he considered that the whole scheme depended on the way in which the examiners conducted their part of the work, inasmuch as they not only recommended what was required, but according to their awards the public money was paid. The professor concluded his remarks by saying that, inasmuch as now every facility had been given to the teachers, he should feel at liberty to be rigidly strict in demanding sound and intelligent instruction being given to the pupils, and he warned all that the plan of driving in to the examination whole flocks of pupils totally unfit to answer a single question, except by a few crammed definitions, would receive no mercy from him in future.

The course which was followed by Dr. Michael Foster was eminently successful, and it may be said that no such course of similar instruction in this subject has yet been given. During the first lecture he gave an outline of the general build of the animal body and its correspondent parts, its cavities and its tissues. From these he divided his subject into—1. The blood. 2. The circulation of the blood. 3. Respiration. 4. Food and its changes. 5. Motion and locomotion. 6. The nervous system. 7. The organs of sense.

The whole of the principles were exemplified by showing the actual organs themselves, either in the sheep, the rabbit, or the frog, care being taken to convince the hearers that all the examples required, even for an advanced course of study, may be obtained without difficulty, for a village butcher, particularly when the teacher was on sufficiently intimate terms with him, might be induced occasionally to cut up his sheep, in a somewhat more physiological manner than usual, in order to preserve certain parts entire.

Many of the mechanical contrivances for showing the action of different parts were highly suggestive to the teacher, and could not fail to be immensely useful to him in bringing home facts to the grasp of his understanding, which mere book-work under the most favourable circumstances could never do.

During his remarks, Dr. Foster touched on some mistakes which he had noticed in the examination papers, and in revising which he had assisted Professor Huxley, as for instance, the definition of the difference between warm and cold-blooded animals, a promising pupil had stated that a warm-blooded animal lived on land, but a cold-blooded in the sea; but thinking this somewhat sweeping, had added, "or near to the sea." He also pointed out the great confusion which exists in understanding the circulation of the blood, a complete grasping of which is necessarily the only foundation on which to build.

It is impossible but that any teacher who has attended this course will return with many valuable ideas of making his science teaching a reality to his class during the coming session.

In consequence of the visit of the science teachers for the purpose of hearing these lectures, Dr. Frankland proposed, in a most disinterested manner, that those of them who were willing should attend at the Royal College of Chemistry, Oxford-street, during the time that they were not engaged at their other duties, and receive some instruction in the system adopted in that college for teaching chemical analysis. On Wednesday, the 30th June, he delivered a most interesting address to all who presented themselves, viz., about 130, pointing out and explaining the glyptic method he uses in explaining chemical combination. He also gave them some suggestions on several points of detail for facilitating teaching, as, for instance, an easy mode of making indestructible diagrams and tables on calico. Those teachers who were sufficiently advanced in practical analysis then attended for several days each, and received a course of teaching from Dr. Frankland's assistants, while those who were not able to benefit thus received several lectures of a more elementary character.

On the whole, it may be asserted that these series of lectures will do more than anything which has yet been carried out to get rid of the cram system of science teaching, and to render it of practical use to the thousands who are now engaged in the five hundred schools and classes existing throughout the country.

Manufactures.

Industrial Arts in Italy. — The following information is afforded by the *Globe*: — "Commendatore Minghetti, the indefatigable Minister of Agriculture, Industry, and Commerce in the Italian Government, has just returned from Venice, where his visit has been hailed as of good augury for the trade of the old Republic. Accompanied by the principal authorities of the city, he visited the exhibition of the celebrated glass-works at Murano, and, after a three hours' examination, bore testimony to the extraordinary development of native industry of which these works give evidence. He afterwards, by command of the King, conferred on Signor Colleoni, the proprietor of the works, the Order of the Crown of Italy, congratulating him at the same time on the well-merited honour. Among other places visited were the Technical Institute and the Upper School of Commerce. Connected with the latter it is intended to found a commercial museum, which the Minister is disposed to aid by a handsome subsidy. Minghetti, it is known, has in view the establishment in Northern Italy of three great centres of professional education in arts and commerce:—Turin, for the strictly technical branches; Genoa, for naval engineering; and Venice, for commerce, strictly so-called, in all its multifarious departments. The Minister, it is also known, takes the warmest interest in the establishment of schools of design throughout the kingdom, and has just expressed to the English Foreign Secretary, Lord Clarendon, his obligations for a large collection of copies and reliefs from the South Kensington Museum, embracing every style of art; a gift which, he says, commands admiration for its beauty, and gratitude for its noble munificence."

The Lighting of Coal Mines.—Mr. Henry Bessemer, in a letter to the *Times*, says:—" The miner, enclosed all day between black masses of coal above and around him, requires a powerful light to see what he is doing—a light that never fails—that never goes out—that never requires trimming—and, above all, a light that effectually prevents the mixture of air and gas, which pervades all coal-mines, from entering the flame and becoming ignited. Now, these are precisely the conditions obtained by combustion under pressure, which offers to the miner a source of the most brilliant light wholly inaccessible to the inflammable air of the mine. As a simple illustration of the fact, let us suppose a small iron box, a little larger than a policeman's lantern, having a thick plate-glass, or a bull's-eye, on one side of it; in the lower part is a common gas-burner supplied by a pipe from a gasometer above-ground; the supply of air to support combustion is arranged in a similar manner, and supplied under pressure from above-ground; a small aperture is made in the top of the lantern for the escape of the products of combustion. Now, if the air and gas is supplied to this light under a pressure of, say, 1lb. per square inch, the light would be brilliant, and the escape from the orifice at this pressure (or even far less) would prevent the possibility of any external gases entering and becoming ignited. In this way every gallery in a mine may be lighted like a workshop, to the great comfort and cheerfulness of those whose whole lives are spent in the cheerless gloom of these dangerous workings. The mode of advancing the light as the work progresses, and its direction by the use of reflectors, and other necessary details of the system are simple enough, and need not be here entered into."

Commerce.

The Duty on Spanish Wine.—In the House of Commons on Thursday, the 8th July, Mr. Akroyd asked the Under Secretary of State for Foreign Affairs if her Majesty's government had received any intimation that the Spanish government is willing to enter into negotiations for a Treaty of Commerce, to be based upon a reduction of their duty on British goods, accompanied by a modification of our duties on Spanish wines above 26 degrees of proof. Mr. Otway replied in the affirmative, and said that the matter was under consideration. The *Produce Markets Review* observes that "it is not likely that any modification can be carried out during the present session, but as our commercial treaty with France will expire in 1870, it seems probable that our whole system of taxing wine and spirits will be revised, and that the changes proposed by the government will form part of the Chancellor's next Budget. We may remind our readers that the subject in immediate consideration affords more than usual facilities for muddling by commercial treaty, and any special legislation requires, therefore, to be jealously watched. When last we wrote on the subject, we quoted one authority who, in reference to an agitation for obtaining an even duty on all wines, whether under or over 26 per cent. of alcoholic strength, remarked that it would be manifestly unfair to admit port wine, fortified up to 40 per cent., which is half the strength of ordinary gin, at a duty of 1s. per gallon, while gin is taxed at 10s. per proof gallon. It was also pointed out that the matter appeared to hinge upon the question, 'What is wine?' for if, as it is asserted, natural wine seldom attains a higher strength than 26 per cent., it followed that all wines exceeding this standard, must, to a certain extent, be fortified with alcohol, and therefore that any extension of the strength allowed to be imported at the 1s. duty, would lead to an increased importation of adulterated wines. Another authority, taking a different ground, seemed to think that the main objection to the present scale was that no medium existed between the 1s. duty, at which 26 degrees of strength are permitted, and the 2s. 6d. duty, which allows 42 degrees of strength. The task of reconciling the conflicting interests of the consumer and the importer, to say nothing of the distiller, with those of the revenue, is one that might well daunt any financier. Indeed, we can scarcely see how any arrangement, even approaching fairness, is likely to be made with our present management of Customs and Inland Revenue. It is possible that a scheme which included a searching reform of both would ensure a considerable amount of popularity, independent of any other merits it might possess, besides affording an able administrator an opportunity of effecting such a saving in expenditure as would make a very respectable addition to the surplus, which is considered essential to every successful budget. Without entering into the question of the advisability of commercial treaties with foreign countries, we will only remark that our bitter experience of the results of the Drawback Convention makes us sorely distrust these engagements, apart from the consideration of their evident opposition to the spirit of free trade."

Selling Sugar at a Loss.—The movement for putting an end to this practice continues in the trade. A meeting of grocers living on the Surrey side of the Thames was recently held, about 250 members of the trade being present. An animated discussion took place as to the best means of putting an end to what was held to be, on all sides, a most iniquitous and demoralising system, of selling sugar at less than cost price, and endeavouring to recoup the loss by excessive profit on other articles. It was unanimously felt that the time had arrived when a determined attempt should be made to abandon the vicious system, and further, that the present juncture was really a crisis, and that the future prosperity of the trade, and its ability to meet the new forms of competition, depended upon whether sugar should continue to be sold at a loss or bear a reasonable profit. A resolution was adopted—"That, from the present time sugar should not be exhibited in shop windows;" and a committee was appointed for carrying out the objects of the meeting.

Colonies.

The Mining Industry in Queensland is in a very satisfactory condition, and is rapidly acquiring increased importance, in consequence of the frequent discoveries of mineral wealth that are being made. This progress has made itself more especially felt within the last year. By the statement of imports and exports of the colony during 1868, it appears that the largest increase in the exports has been in the value of gold. In 1867, the amount was £189,248; last year it was £593,516, which shows an increase of £404,268 on last year's operations in this direction. The value of the exports of copper and copper ore has increased during the same time from £66,038 in 1867 to £72,136 in 1868.

Taranaki Steel.—A New Zealand paper says that several specimens of Taranaki steel have been taken to England, smelted from the Taranaki steel sand, which is said to contain 75 per cent. pure steel. Samples of both crude and manufactured have been sent.

Publications Issued.

Cassell's Popular Educator. (*Cassell, Petter, and Galpin.*) This work has now reached its twenty-first number. It contains articles on electricity, readings in Greek, lessons in botany, algebra, light, natural history, &c. Among other subjects is one of somewhat novel and considerable importance, especially interesting to artisans, viz., the "Natural History of Commerce," which is intended to be a reply to the questions—"Whence do we derive the raw materials which are the staple of our commerce and industry?" "Why do we find them in particular localities?" "What constitutes their true value?" "Are there yet no undeveloped regions or natural products?" A series of lessons on this head will appear, from time to time, in the numbers as they come out.

Correspondence.

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National Musical Education.—Sir,—I read in the *Journal* that some steps are being taken towards the establishing of a system of musical education in this country. I presume you will not object to a few observations on this subject. I may say that I am correspondent to the Science and Art Department on behalf of the Eagley Institute; am also a manager of the British School at Eagley, and a leading director of a large Sunday-school; I am also a member of a large choir, and am intimately acquainted with music, and a tolerable performer on the violoncello. The expression of my opinion, therefore, on the subject of musical education I hope may be permitted. I have long been of opinion that music, as an art, has been shamefully neglected by the government of this country, and I think the time has now arrived when an attempt should be made to place musical matters on a better footing. At present it is a known fact that conductors of concerts, such as Mr. Charles Hallé, experience the greatest difficulty in finding solo singers fit to appear before a respectable audience, and this difficulty, I am informed, is yearly increasing. In towns, such as Bolton, the resident musical professors are woefully behind the age, in fact are little better than quacks, hold no certificate or diploma of any kind, as a general rule, and, instead of doing credit to the profession, only seem to sink it still deeper in the mire. I fancy the same opinion might safely be ventured respecting most of the provincial towns of England. In fact, music in this country, as a general rule, means strumming and thumping a few tunes on the piano, and nothing more. I think it would be a good thing if "music" could be added to the list of subjects encouraged as a branch of national education. Examinations in vocal music, and in the theory of music, might easily be got up, and some uniform system of teaching singing, &c., might be adopted officially. If some system of the same kind could be extended to schools under the inspection of the Committee of Council on Education, I think the results thereof would be good. The whole subject, in my opinion, is an important one in a national point of view—important as bearing upon the health, the morals, and the intellect of the people, and I should rejoice exceedingly to see something done in the direction I have pointed out.—I am, &c., Gervase Marson.

Eagley Mills, near Bolton, July 28, 1869.

Patents and Patent Laws.—Sir,—The paper upon this subject that appeared in your issue of the 30th ult., by Mr. W. Bridges Adams, is the most elaborate and talented specimen of special pleading that has been produced for some time past. That gentleman condemns the argument of the opponents of those laws as mere assertions; but what are the writer's own arguments other than mere assertions, which are contradicted by the history of the world; for have not all the millions upon millions of the appliances of civilised life, which we have enjoyed from the Creation to this day, been the produce of inventive genius ages before such laws were thought of, much less put in practice? The "monopoly" of the patent laws was first devised in barbarous times, when men, women, and children were burnt alive for witchcraft or creeds, and talented and learned men were searching after the philosopher's stone, the elixir of life, and the transmutation of metals. The translation of the term "patent" as open, is invidious, for the so-called open specifications of a patent are locked-up from the public for fourteen years; and, long before the expiration of that period, either the fashion has changed, or the invention has been superseded by other methods or improvements. Of what use then to the public is the open specification? The argument that the patent law is a benefit to the poor man, is controverted by the notorious fact that the only benefit, if any, falls to the rich and powerful, especially to the professors of the law, to whom it affords a very plentiful harvest. The poor man cannot afford the expense of a patent; and if he could accomplish that object, he cannot stand that of a suit in Chancery, which, according to the opinions of some, is indispensable to confirm the validity of any patent. The possible benefit to the patentee in the aggregate, is contradicted by the fact that ninety-nine out of every 100 patents obtained produce no remuneration whatever; especially, as in most cases, a large succession of riders to the original are required to ensure the first, and many patentees are ruined in the process. It is true that patent rights offer a glorious advertisement to rich tradesmen, with their heading "Her most gracious Majesty has been pleased to grant Royal Letters patent for the manufacture of our improved patent needle-case," &c., implying, thereby, that the Royal Letters Patent prove the superiority of the invention to any other. It must always, however, be borne in mind, that every expense incurred for letters patent, advertisements, or other matters, must eventually come out of the pocket of the consumer, not out of that of the tradesman. The writer truly states that manufacturers will not accept any improvement or novelty unless already protected by patent right; but it is the very existence of such laws that cause this state of things; and if they had not existed, or were now abolished, the manufacturer would be compelled, by public competition, to adopt new inventions, from whatever source they might spring. Again, he says, that the abolition would cause all new inventions to be carried over to those countries where patent laws still exist. But what possible harm could befall us if such proceedings really did take place? We should freely enjoy the benefit of those inventions, because they could not be patented in this country. Mr. Adams pins his faith upon the possibility of obtaining good patent laws, but the whole drift of his paper tends to show the impracticability of any such being enacted. If all applications for exclusive rights are to be judged by a committee of scientific men, both the expense and the delay would become intolerable; especially seeing that a first specification is usually very imperfect, obscure, and replete with errors. The public must be the judge, but it will be impossible to obtain that judgment until the invention shall be brought out and in use. Also the proposal to raise the cost of patent rights to an enormous sum, or to reduce it to the means of a poor man, are both equally absurd. In fact, the patent laws are neither more nor less than an authorised ruinous lottery. That every intending patentee should, as some say, be bound to make himself acquainted with every previous patent, is an impossibility, for his whole life might perhaps be insufficient to go through the process. For these and a hundred other incontrovertible arguments, I advocate the total repeal of the patent laws, either immediate or prospective, as may be deemed advisable upon mature consideration.—I am, &c., Henry W. Reveley.

1, Baker-street, Reading.

PARLIAMENTARY REPORTS.

SESSIONAL PRINTED PAPERS.

Par. Numb. *Delivered on 24th July*, 1869.

231. Bill—Irish Church (Lords Amendments, &c.).
232. „ Irish Church (Commons Amendments, &c.).
233. „ Telegraph (as amended by the Select Committee).
234. „ Heritable Rights (amended).
235. „ Nitro-glycerine (amended).
237. „ Zanzibar (Jurisdiction of Consul).
319. Drunkenness, &c.—Return.
339. Lunacy (Ireland)—Return.
Public Petitions—Thirtieth Report.

Delivered on 26th July, 1869.

236. Bill—Volunteer Act (1863) Amendment.
293. Reserve Squadron—Extracts from Report.
306. Contagious Diseases Act (1866)—Report.
348. Telegraph Bill—Report.
Customs—Thirteenth Report of the Commissioners.

Delivered on 27th July, 1869.

228. Bill—Militia (Ireland).
238. „ Metropolitan Board of Works (Loans) (as amended by the Select Committee).

303. Public Accounts—Third Report and Evidence.
328. Ecclesiastical Commission (Ireland)—Annual Report and Account.
341. Fines, &c. (Ireland)—Abstract of Accounts.
333. Metropolitan Commons Act (1866) Amendment Bill—Special Report.
Post Office—Fifteenth Report.
China (No. 12, 1869)—Correspondence.
China and Japan—Reports of Journeys by Mr. Alabaster, &c.

Delivered on 28th July, 1869.

239. Bill—Charity Commissioners.
240. „ Accounts, &c., Presentation.
241. „ Bishops' Resignation.
242. „ Seamen's Clothing.
243. „ Queen Anne's Bounty (Superannuation Allowances).
312. East India (Army)—Return.
340. Merchant Shipping—Accounts.
353. England and France (Channel Passage)—Report by Captain Tyler.

Delivered on 29th July, 1869.

227. Bill—Hackney and Stage Carriages Law Amendment.
2. (8) Railways Abandonment—Warrant.
277. Savings Banks—Return.
352. Parliamentary and Municipal Elections—Report.
354. Dockyard Emigrants to Canada—Extracts from Reports.
364. Greenwich Hospital—Estimate.
Cape of Good Hope and Natal—Despatches.
Public General Acts—Chap. 32 to 42.

Delivered on 30th July, 1869.

244. Bill—Sanitary Act (1866) Amendment.
46. (v.) Trade and Navigation Accounts (30th June, 1869).
351. East India Railways—Despatch.
355. Civil Services—Supplementary Estimate.
363. Revenue Departments—Supplementary Estimate.

Delivered on 31st July, 1869.

245. Bill—Expiring Laws Continuance.
249. „ Bankruptcy (Lords Amendments).
289. East India (Cotton)—Report.
303. (I.) Public Accounts—Supplement and Appendix to Third Report.
323. Grand Jury Presentments (Ireland)—Abstract of Accounts.
335. Seeds Adulteration Bill—Report and Evidence.
Public Petitions—Thirty-first Report.

Delivered on 2nd August, 1869.

246. Bill—Offices Abolition.
247. „ Dividends on Public Stocks.
250. „ Harbour of Galle Loan.
251. „ East India Loan.
334. Distillers, &c.—Return.
338. County Voters (Scotland)—Return.
350. Dogs Regulation (Ireland) Act, 1865—Account.
368. Dividends on Public Stocks—Correspondence.

Delivered on 3rd August, 1869.

73. (A.) Bill—Habitual Criminals (Amendments by Mr. Bruce).
248. Bill—Prevention of Gaming (Scotland).
252. „ Imprisonment for Debt (Lords Amendments).
253. „ Canada (Rupert's Land) Loan.

Delivered on 4th August, 1869.

255. Bill—Contagious Diseases.
256. „ Presentation of Benefices belonging to Roman Catholics, &c.
257. „ Contagious Diseases (Animals) (Lords Amendments).
358. Magistrates (County Palatine of Lancaster)—Return.
359. Friendly Societies—Return.
365. Marylebone (Southall Schools)—Correspondence.
381. New Law Courts—Report from the Select Committee.
Public Petitions—Thirty-second Report.

Patents.

From Commissioners of Patents' Journal, August 6.

GRANTS OF PROVISIONAL PROTECTION.

Alcohol and paraffin, purifying—2241—J. H. Johnson.
Artificial marble or stone—2238—W. Lincolne and E. Chafer.
Bale ties—2201—J. W. Larmuth.
Boilers—2209—G. Allibon and A. Manbré.
Candles and soap, treating tallow used in the manufacture of—2059—W. Davis.
Carded wool, spinning on small cops—2205—W. Brookes.
Carding engines—2215—A. M. Clark.
Carding engines—2270—R. Shaw and R. Lakin.
Carriages, machinery for propelling—2248—W. Dredge and A. Stein.
Cartridges, &c—2257—D. H. Brandon.
Cask stands—2079—T. D. Waller.
Coal, removing sulphur compounds contained in—2233—T. Barnes.
Collars and false collars for horses, &c.—2251—C. L. Caldesi.
Compasses—2271—J. Miller.
Cooking, and the means and articles employed—2239—E. Stevens.
Dry earth closets—2277—D. T. Bostel.
Fabrics, apparatus employed in the manufacture of looped or knitted—2263—E. Attenborough
Feed-water, &c., apparatus for heating—2254—T. Auchincloss.
Files and rasps, cutting—2169—W. Furness.
Fire-arms, breech-loading—2267—E. Ginder.
Flax, &c., machinery for hackling—2244—S. Cotton.
Furnaces, &c.—2256—W. Tongue.
Girders—2272—C. Henderson.
Hats, &c.—2246—I. Frankenburg and S. Phillips.
Heat, apparatus for abstracting—2211—A. C. Kirk.
Hoists, working—2128—J. Crowther.
Hops, preserving the aromatic principle of—2227—W. A. Gilbee.
Horses, &c., apparatus for clipping—2217—H. Knight.
Iron, &c., coating with tin—2268—W. E. Tilley.
Iron ores, preparing for smelting—2265—C. Cochrane.
Lamps—2243—S. Bishop.
Lithographic and zincographic cylinder printing machines—1489—C. H. Gardner and J. Bickerton.
Medicaments for internal and external use—2274—J. Winship.
Metals, apparatus for annealing—2133—B. J. B. Mills.
Metals, preventing from rusting—2284—F. Crossley.
Mortising machines—2252—G. N. Blane.
Night soil, &c., treating—2269—J. H. Johnson.
Paper, manufacturing—2282—D. A. Fyfe.
Pillars for straining and supporting wires for fences, &c.—2255—C. Y. Michie and G. W. Murray.
Pipe and tube joints—2240—J. H. Johnson.
Pumps—2249—R. Pictet.
Railways, &c.—2247—H. Greaves.
Reaping and mowing machines combined—2261—J. G. Rollins.
Reeds, machinery for combing—2259—T. Winter.
Refrigerating and freezing apparatus—2245—W. Mort.
Rotary engines—2207—G. H. Ellis.
Sewing machines—2221—W. H. Gosling.
Ships' anchors—2225—W. Warren.
Shuttles—2258—W. Crossley and J. W. Swithenbank.
Spades and shovels, coffered—2275—I. Barker.
Sugar, manufacturing and refining—2280—A. M. Clark.
Tap and filter combined—2203—J. Ogden.
Teetotums, &c.—2113—R. Whitaker.
Telegraph wire insulators—2235—W. R. Lake.
Tramways, points or switches for—2237—W. Morris.
Tyres of iron or steel—2278—J. Windle.
Valves—2264—B. Hunt.
Velocipedes—2129—J. Crowther.
Velocipedes—2231—J. G. Wilson.
Votes by ballot, apparatus for taking, &c.—2223—W. H. Stone.
Watches, &c., winding up—2286—A. Burdess.

INVENTIONS WITH COMPLETE SPECIFICATIONS FILED.

Looms—2287—H. A. Bonneville.
Looms, &c—2288—H. A. Bonneville.
Railway breaks—2310—J. Beckett.
Steam engines—2311—W. R. Lake.
Wool, &c., mechanism for spinning—2329—J. Bapty and A. Hall.

PATENTS SEALED.

380. T. Nichols and J. Parr.
385. O. Sarony.
395. J. and G. W. Dennell.
396. J. Wilkinson and W. Scott.
407. G. Gros.
410. J. Stuart.
412. W. Lever.
414. C. T. E. Lascelles.
416. J. F. Bentley.
420. J. Clayton.
427. P. J., F. W., and H. G. Smith and A. Pappenberger.
438. W. H. Hayhurst.
492. J. Darlington.
1253. W. B. Dick.
1504. D. Hitchen.
1581. W. Morris.
1868. W. R. Lake.
1869. W. R. Lake.

From Commissioners of Patents' Journal, August 10.

PATENTS SEALED.

434. H. Edwards.
437. F. J. Vandenvinne.
440. T. V. Trew.
441. G. H. Morgan.
446. C. Gordon.
448. J. Holmes.
451. E. G. Brewer.
476. J. Fletcher.
479. J. W. Yates.
499. J. A. Wade and J. Cherry.
539. J. and W. Weems.
599. J. T. H. Richardson.
602. J. Reap and W. H. Michelmore.
607. W. Thomas and W. Davis.
767. J. Cooke.
918. T. Sowden and J. Newton.
922. H. Downie and I. B. Harris.
934. J. W. Girdlestone.
944. A. Clark.
1011. J. Howden.
1180. J. H. Johnson.
1289. R. Sterne.
1526. E. C. Warburton.
1574. J. Platt.
1691. H. Browning.
1739. H. Downie and I. B. Harris
1756. J. G. McKirdy.
1871. T. Bourne.
1917. D. B. Park.

PATENTS ON WHICH THE STAMP DUTY OF £50 HAS BEEN PAID.

2059. C. F. Cotterill.
2113. W. Tranter.

PATENTS ON WHICH THE STAMP DUTY OF £100 HAS BEEN PAID.

2198. J. Townsend.
2227. J. Tatham.
2311. S. A. Bell and T. Higgins.
2448. H. L. Emery.